Analysis of Sustainability for Colombia, with particular attention to the role of water resources

Margarita Maria Parra-Cobaleda

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Abstract

This thesis strives to gain an understanding of the intricate issues surrounding ideas such as development, people's quality of life, water resources use and sustainability in the context of a country as complex as Colombia.The initial hypothesis was to determine whether Colombia could offer to its people a sustainable living. Having dealt with this, the following question was to determine the key role of water in the sustainability labyrinth and the ways to address the problems standing in the way of water and a sustainable living.

Hartmut Bossel's analytical framework based on systems theory was used to define sustainability indicators for Colombia. The present failure to satisfy Colombians' basic needs illustrates how the country is not offering its people a sustainable living. The specific analysis of the indicators through the use of conceptual models suggested that the link between quality of life and water resources via water accessibility is crucial for the sustainability of the whole.

Systems and holistic thinking enabled this thesis to come up with principles for working towards overcoming the unsustainabilities. The discussion led to conclude that a holistic approach is particularly important to address water accessibility and subsequently sustainability in Colombia.

Ultimately, if Colombians can satisfy their basic needs, of which water accessibility is just one, it will free them up and enable them to tackle other issues related with quality of life in their society such as corruption and violence, as well as appropriate management of their resources. This will give rise to a sustainable living for the people of this land in South America

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List of Abbreviations

DANE: National Statistics Department of Colombia
DNP: National Planing Department of Colombia
FAO: Food and Agriculture Organisation of the United Nations
IDEAM: Institute of Hydrology, Meteorology and Environmental Studies of Colombia
INEGI: National Institute of Statistics, Geography en Informatics of Mexico.
LE: Life Expectancy
OPS: Pan-American Health Organisation
ODHC: Observatory of Human Rights in Colombia
UBN: Unsatisfied Basic Needs
UNESCO: United Nations Educational. Scientific and Cultural
UNFPA: United Nations Population Fund
WB: World Bank
WHO: World Health Organisation
WRI: World Resources Institute

Chapter 1. Introduction

1.1 Justification for the research interest

As a result of prior studies at the Centre for Development Studies in Trivandrum, India, a project report on the interrelationship between Bogotá and its environment, in the context of the rapid urbanisation of Colombia, was elaborated. The bases of this project report were the previous work experience with a non-governmental organisation in projects involving poor urban communities of the city, mainly in finding solutions for solid waste management and wastewater problems.

The conclusions of the project report were focused, in the one hand, in three major environmental problems of the city: the growing demand for resources (such as *water*, fuel, food, etc), the air and *water* pollution, and the dynamic urban-rural interface of the city. On the other hand, it was concluded that inside the city the crucial problems for the majority of Bogotá's dwellers were the lack of adequate transportation systems and the *water* and *sanitation* infrastructure.

Determining ways to address these problems as a further step was considered to be worthy of research. It was recognised that the solution to these environmental problems is complex and it requires looking at on a broader scale. Political, social, economic, and technical dimensions have to be considered. S*ustainability, sustainable development, systems thinking,* and *complexity* appeared to be possible answers and thus potential topics to investigate.

1.2 Aims of the research

The central aim of this study is to develop an analysis of sustainability for Colombia with a systems and interdisciplinary approach. In addition, two specific aims are intended:

- To understand the concept of sustainability, its background, appropriateness and/or constraints in the context of a developing country with all the particulars of Colombia.

- To identify the main factors preventing Colombia from sustainability, *unsustainabilities,* and to determine appropriate approaches to address them. Specifically, the key role of water and the ways to address the problems standing in the way of water sustainability will be studied.

1.3 Thesis outline

In order to fulfil these aims the thesis has been structured as follows:

- The meaning of what sustainability involves is examined in chapter two. The discussion on the meaning of sustainability and the adopted statement enable us to propose a more specific research question within the central aim of this thesis based on the satisfaction of basic needs.
- Chapter three presents the use of systems thinking as one essential element for the research. Specifically, Hartmut Bossel's analytical framework to analyse sustainability is outlined.
- The indicators of sustainability for Colombia defined by following Bossel's method are described in chapter four. The selection criteria for the indicators and the difficulties encountered applying Bossel's method are mentioned.
- Chapter five deals with the sustainability analysis based on the indicators. A specific analysis is elaborated through the use of conceptual models. Quality of Life and water resources are studied further as vital elements of Colombian sustainability. Water accessibility is determined as one essential basic need of the system.
- The discussion in chapter six leads to postulate and explore a holistic approach to address water accessibility and, subsequently, sustainability in Colombia.
- Finally, chapter seven presents the conclusions and recommendations of the research.

1.4 Colombia: The context of study

Before getting started, a brief description of Colombia is presented for readers who are unfamiliar with this country. Colombia is located on the top northwest corner of South America. Panamá surrounds it in the northwest, Venezuela in the east, Brasil in the southeast and Perú and Ecuador in the south.

Colombia is the fourth largest country in South America, with 1,139,000 sq. km (four times New Zealand). It is divided into 33 departments or provinces; the capital is SantaFé de Bogotá, which is also the capital of the province of Cundinamarca.

The country comprises flat coastal lowlands; the high Andes Mountains, which run north south; eastern lowlands plains and the tropical rain forest of the Pacific coast and of the Amazonas jungle at the southeast. The climate of the coastal lowlands and the eastern plains is tropical whereas the highlands have much cooler weather.

Numerous indigenous groups inhabited the country before the Spanish colonisation; Chibchas were the main ethnic family. At present the population of the country is a mixture between mestizos (of European-Indian descent), mulatos (African-European descent), zambos (African-Indian descent), negros (African descent), and indigenous, the last two being minorities.

Colombia got its independence from Spanish rule in 1819 and since then only two traditional parties have ruled the country. This has engendered a significant and outlawed opposition from leftist guerrillas groups and as a result, the country's democracy has been in conflict with more than 40 years of violence.

Chapter 2. Understanding Sustainability

Many authors, especially in the last forty years, from different perspectives have discussed in books, journals, speeches, policies, aid programmes, and summits the meaning, conditions and routes to sustainability. As a result, there are quite a number of definitions and approaches that sometimes disagree with each other.

Underneath the academic and political debate about definitions on sustainability, are however the causes that have led people to start discussing it and these are more important. People from all over have questioned the way human activity interacts with the environment. Besides, relations between north and south, and inequalities between different populations have also been recently included in the discussion of sustainability.

In this chapter a concise introduction to this debate is presented, attempting to understand the intricate issues surrounding ideas such as development, people's quality of life and sustainability in the context of Colombia and Latin America. Some background issues are discussed, a definition of sustainable living is adopted and a more specific research question is proposed.

2.1 Sustainability debate

The origins of the academic discussion of the conflicts between population and environment are dated from the work of Thomas Malthus at the end of 18th century. His *Essay on the Principle of Population* was published in 1798 and there were later editions. As an economist, Malthus studied the relationship between population and food production concluding that there were limits for human population growth (Pickering, 1997).

There are various historical and contemporary examples of what is called Malthusian Views (Pickering et al, 1997). A historic example is the collapse of the Maya civilisation. The Maya's noteworthy society developed in areas where obtaining food for the growing population would have been a major challenge, in Central America's tropical jungle

(Pointing, 1990). Clive Pointing explains how the growing Mayan population was fed by intensive agricultural systems that eventually broke down due to environmental degradation (Pointing, 1990).

In the 20th century more examples of global environmental problems, and their relation to contemporary development models, have made this debate more vigorous. In the last 40 years, numerous international conferences have been held with the aim of discussing these conflicts. The Club of Rome in 1972, the UN-conference on Human Environment in Stockholm in 1972, the World Conservation Strategy in 1980, Our Common Future - Brundtland Report in 1987, Rio Conference in Environment and Development in 1992 and Rio Plus 5 in New York in 1997 are among the most well known.

Some of these conferences, and their leaders, still maintain the Malthusian view, arguing that the main cause of global environmental degradation and resource crisis is population growth. Nevertheless, there is little attention given to how some ways of development (of which agriculture and food production is crucial) can lead to more environmental conflicts.

Since the publication of *The Brundtland Report* in 1987, sound international institutions such as the United Nations and the World Bank (which in some senses hold a narrow Malthusian view) have advocated sustainability as a goal and solution for these environmental conflicts. Sustainability is viewed as the new direction of development, in the belief that development will, through economic and social reforms, bring something better called *sustainable*.

However, *sustainable development* has been rather a fashion word or a distraction because the world continues to be run and developed in an unsustainable way. Vandana Shiva an Indian scientist states: "the term *sustainable* entered the economic development lexicon in the 1980s when people began to realise that economic growth and continuous increases of per capita income were unsustainable" (Shiva, 1992 in Krishnan et al, 1995:86) [italics as in the text]. Thus, what is unsustainable is the social and economic development of the wealthier or developed nations, leaving the term *sustainable* contestable in the South, where the benefits of *development* have not been reached yet.

Michael Redclift makes it clear by affirming that "whether or not development is necessarily unsustainable, as Trainer (1986) and Bahro (1982) argue, it is clearly unsustainable on current models for many of those whose livelihoods are made in the South, and for reasons that lie outside their control" (1987:201).

Furthermore, some authors who hold an anti-Malthusian view affirm, "too often there is an inappropriate use of technology, over-consumption and inequalities in wealth and life chances, which ultimately induce environmental degradation rather than simple overpopulation" (Pickering, 1997:411).

Therefore, *development* and *sustainable* seem contradictory ideas; current *development*, although it has increased the quality of life of a few, has been achieved on the basis of resource exploitation, environment degradation and most significantly on the basis of social inequalities. Moreover, the linkage between the affluence in richer countries, as a result of *development*, and the poverty in the countries of the south is something deliberately missed or dismissed in some definitions of sustainability. Trainer stresses that "material standards of life in the developed countries are intimately linked with the way resources and human labour are exploited in the South" (Trainer, 1986 in Redclift, 1987: 201).

Addressing sustainability, meaning merely resolving the conflicts within populations and between them and their environment, in the current development models implies, then, more than a simple fashion word. Drummond and Marsden assert that "although the nature of present day modes of development is such that various forms of unsustainability are the norm, as it has been in our case studies of agricultural development, most current attempts to promote sustainable development still focus on the explicit outcomes produced rather than the underlying causes" (1999:205). In consequence they confirm: "some writers not only reject neo-liberal approaches but suggest that sustainable development can only be achieved within a socio-economic order radically different from that which exists today" (Drummond and Marsden, 1999:17).

Clayton and Radcliffe extend this by asserting: "it is also the rich nations that have the skills, resources and political and economical power to start to develop solutions to these problems" (1996:209). Thus, tackling social and environmental problems in the countries of the south

and achieving global sustainability raises questions with complex answers. It involves thinking about a new equilibrium and working towards a new order and relationships.

2.2 What does sustainability mean for Colombia?

Colombia is a country of the south. Colombia, and Latin America as a region, present high income inequality and poverty. A recent World Bank paper shows that "throughout the post-world war II period, income inequality in Latin America has remained the highest in the world. During the last 20 years, this persistent inequality combined with mediocre economic growth, led to 50 million more poor people in the region, the highest increase in absolute terms in the 20th century (Londoño, 1996:35).

Accordingly, Goodman and Redclift, who specifically studied sustainability in Latin America, concluded: "in situations like those of tropical Colombia and Brazil we need to specify greater equity, or reduction of poverty, as *primary* objectives of sustainable development, before the question of environmental quality can be fully addressed" (1991:6) [italics as in the text].

Hence, more urgent needs in the region and in Colombia, such as alleviation of poverty, leave the conflicts with the environment second in the line. However, these problems are interconnected. Precisely, the type of *development* experienced in the region, in economic terms, has been primarily based on resource exploitation, which has resulted in poverty and environmental degradation. From the Spanish colonisation, indigenous populations of the Andean Region of South America saw themselves being slaves of the European greed for gold and silver. Later on, international trade of resources such as coffee, bananas, petroleum, carbon, forest, flowers, and even illegal crops, continues to exploit the peoples and the land.

On the other hand, the region has the highest degree of urbanisation in the world, resulting from industrialisation, another type of development, and the rural crisis. Cities such as Mexico city, Saõ Paulo, Rio de Janeiro and also Bogotá have more than or around 10 million inhabitants. Nevertheless, the city's capacity to provide services and jobs is not sufficient for all dwellers. As a consequence, poverty continues to be attached to the modes of *development.*

Thus, to address poverty *and* environmental problems in Colombia and Latin America, as primary steps for sustainability, *development* needs indeed to be reconsidered and redirected, not only locally but also at the global scale as pointed out earlier. With regard to this, Vandana Shiva believes "the sustainability challenge for the new millennium is whether global economic man can move out of the worldview based on fear and scarcity, monocultures and monopolies, appropriation and dispossession and shift to a view based on abundance and sharing, diversity and decentralisation, and respect and dignity for all beings" (Shiva et al, 2000:79).

Before our global civilisation becomes subject to a Malthusian prediction this is something that can be done. Work towards understanding the specifics of the problems can contribute to a shift in the worldview. Here is where this research thesis fits in the big picture.

2.3 Sustainable living: a working definition

Trying to define sustainability will always be a difficult issue. John and Katherine Peet have come up with a valuable statement; for them, rather than a definition, sustainability is in the form of an ethical principle, as they state: "for sustainable living all people have their basic needs satisfied, so they can live in dignity, in healthy communities, while ensuring the minimum adverse impact on the natural system, now and in the future" (Peet and Peet, 2000:3).

This statement wisely recognises all communities of the world, emphasising that improvements for peoples' quality of life, by satisfying their basic needs, are required now and also in the future. This statement also stresses awareness of the need to minimise the impact of all human activities on nature. This is the starting point for this research.

2.4 Assessing sustainability: a research question

The discussion about the meaning of sustainability and the adopted statement lead to a more specific research question within the central aim of this thesis: Could Colombia offer to its people a sustainable living?

Assessing sustainable living in Colombia becomes the next task. In order to determine whether a community has all its basic needs satisfied, information about the community and its environment is required. Although this task becomes difficult when the dimension of a country is considered, systems thinking will enable us to deal with the complexity. Specifically, Harmut Bossel's analytical framework for defining indicators of sustainability based on systems thinking will be used in gaining understanding about the state of the system. The following chapter will describe the particulars of systems thinking and Bossel's method.

Chapter 3: Systems Methodology

Having explored and understood sustainability, the next step towards the aim of this thesis work is to assess the state of Colombia with regard to the sustainable living definition. In order to do so a systems methodology has been selected, specifically Hartmut Bossel's framework for defining sustainability indicators. This chapter presents an introduction to systems thinking and an explanation of Bossel's method and principles.

3.1 Systems based approach

The systems approach and its principles allow us to identify all the system's elements and their relationships. It is an integrated and holistic way of thinking that enables us to look at research problems on a broader scale. Systems thinking was developed in several different disciplines and activities as a response to certain problems faced by traditional sciences, such as complexity and the disjunction between the social and natural sciences, a division that was arbitrary and man-made (Checkland, 1981).

A system is defined as anything that is composed of elements, which are connected in a characteristic structure and perform specific functions within the system's environment (Bossel, 1998). However, complex systems, which are ultimately the ones of interest here such as a country or a community, are not easy to break into or reduce to parts. The most significant property of a complex system is the inter-connectedness and interdependence of its elements. Thus, a complex system has emergent properties (such as the degree of complexity) that only become apparent from the interaction between its parts (Elms, 1992).

A very pedagogic way to understand complex systems has been recreated by Bossel and Peet. It is the analogy of a frog and a bicycle; both are systems, but bicycles are not as complex as frogs, since

"..one can take a bike to bits, clean and oil it, inspect and service the parts and reassemble it, confident that it will work as well as before. Frogs can't be treated that way – the moment you take away any significant part, both it and the frog itself are irreversibly affected" (1998:2)

The importance of systems analysis and recognising the complexity of sustainability analysis is therefore evident. Sustainable living for a community involves looking at every dimension; although it is individually about household economy, government social policies, and scarcity of resources, it is more about the study of the interdependence and relationships between all of these dimensions. As Peet asserts, people, society, economy and nature are inextricably linked together, engaged in continuous change and interplay with each other, directly and indirectly (Peet, 1999a).

Furthermore, an integrative systems approach to the question of sustainability takes into consideration ethics and stakeholder involvement (Peet, 1999b), enabling a place for all communities and peoples, and all wisdom and knowledge. In a world where indigenous peoples, peasants and poor urban dwellers in Third World countries (and some in the First World too) have been restricted and are working towards empowerment, this approach is very valuable.

3.2. Hartmut Bossel's analytical framework for developing sustainability indicators

Hartmut Bossel, a systems theory researcher, has developed a framework for the analysis of sustainability for complex systems. One of the main outcomes of his methodology is a set of indicators, here named sustainability indicators. The indicators' objective is to assist in identifying the fundamental needs of a complex system through identifying those parts where the condition of one or more key state variables may threaten the viability of the whole system (Peet and Bossel, 1999). The indicators provide information for specific areas of the system that in the methodology are called **orientors** of the system. Ultimately, the orientors correspond to the needs of the system to be viable and sustainable. In order to understand this methodology in more detail the following dialogue is provided.

3.2.1 What is the system?

In Bossel's framework for analysing sustainability the whole system is the anthroposphere, and it is represented through the connection of three subsystems: human, support and natural, see Figure 3.1

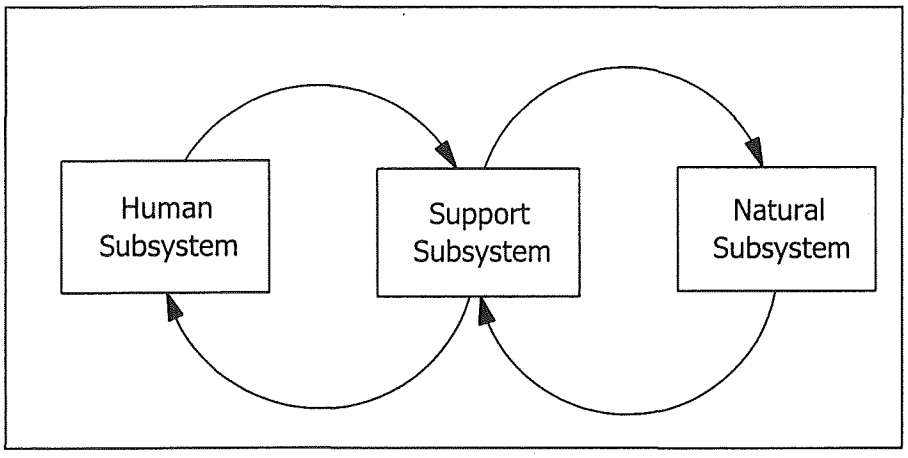


Figure 3.1 Bossel's model: A World of Systems[1]
Source: Bossel, 1999

According to this model[2] each subsystem is connected directly or indirectly to the others with circular flows and feedbacks. However, Bossel's model does not suggest a direct relationship between the natural and the human subsystems. It is implicit that humans relate to their environment through the support subsystems; for example, peoples' need for food is satisfied through agriculture production and distribution systems. Nevertheless, when applying this model certain exceptions can be found especially in regard to the traditional communities of Colombia. Indigenous peoples relate completely differently to nature from the way Western societies do. The relationship between Colombians and water, as a natural resource, will be explored further in the analysis of sustainability of chapter five.

3.2.2 What are the system's elements?

Each of the subsystems, human, support and natural, is the aggregation of different sub-subsystems, as shown in Figure 3.2. Clearly those sub-subsystems are complex systems themselves. The main principle implied in this system's methodology is that the viability and

[1] This drawing is depicted from Bossel's Fig. 3 page 18 of the cited source.
[2] The concept of 'model' is expanded further in Chapter five.

sustainability of the total system depends on the proper functioning of all sub-subsystems and the key relationship is the reciprocity between them (Peet and Bossel, 1999).

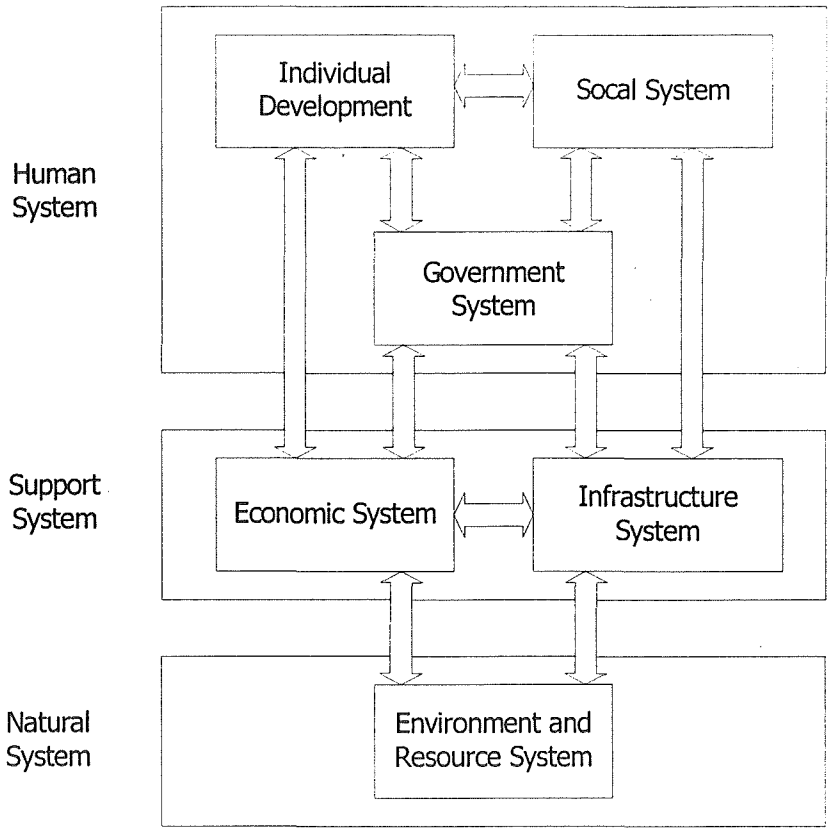


Figure 3.2. Bossel's detailed model: the components of the anthroposphere and their major relationships
Source: Bossel, 1999
Note: In the upper part of this diagram Socal should read Social.

All of the six sub-subsystem components, from Figure 3.2, are essential parts of the anthroposphere and they represent a **potential** that is essential to the development of the total system and that must be sustainably maintained. For Bossel the term **potential** "denotes a stock or capital[3] of a vital asset, which can grow or depreciate, and must be maintained in good state in order to contribute its share to the development of the total system" (1999:18). Bossel expands the contents of each potential as follows (1999):

[3] In this context the use of the term capital could be dubious since this notion has still strong linkages with neo classical economics and it is easily interpreted as exclusive and related only to income (Peet and Bossel,1999).

- Individual Potential describes the potential for competent individual action as produced by and producing the possibilities for individual development. It is the accumulated result of tradition and culture as well as socio-political and economic conditions.
- Social Potential relates to the ability to deal constructively with social processes, and employ them for the benefit of the total system.
- Organisational Potential is manifested in the know-how and performance standards of government, administration, business and management. It is vital for effective resource use for the benefit of the total system.
- Infrastructure Potential denotes the stock of built structures like cities, roads, water supply systems, schools and universities. It is the essential backbone of all economic and social activity.
- Production Potential (of the economic subsystem) includes the stock of production, distribution and marketing facilities. It provides the means for all economic activity.
- Natural Potential represents the stock of renewable and non-renewable resources of materials, energy and bio-systems, including the capacity for waste absorption and regeneration.

3.2.3 What are the system's needs?

For the development and maintenance of every **potential** in any system there are **basic needs** that should be satisfied. To identify those fundamental needs, Bossel's framework is based on the analysis of the properties of the system. Every system exists within a surrounding context or environment. The relationship between a system and its environment determines its properties, accordingly Bossel identifies six properties for the system's environment: normal environmental state, resource scarcity, variety, variability, change and other systems (Bossel, 1999).

The way that the system interacts and responds to its environment leads to the recognition of **orientors**. The orientors are the counterparts of the fundamental properties of the system. Since each of the environmental properties causes a specific basic system need, "basic orientors are ultimately the system's basic needs" (Peet and Bossel, 1999:7). These basic orientors corresponding to the six fundamental properties are existence, effectiveness, freedom of action, security, adaptability and coexistence. They are called 'environment-

determined basic orientors'. However, there are other orientors, which apply to self-reproducing, sentient and conscious systems. These are reproduction, psychological needs and responsibility, and they are called 'system-determined basic orientors'. The properties as well as the orientors of a system are represented in Figure 3.3

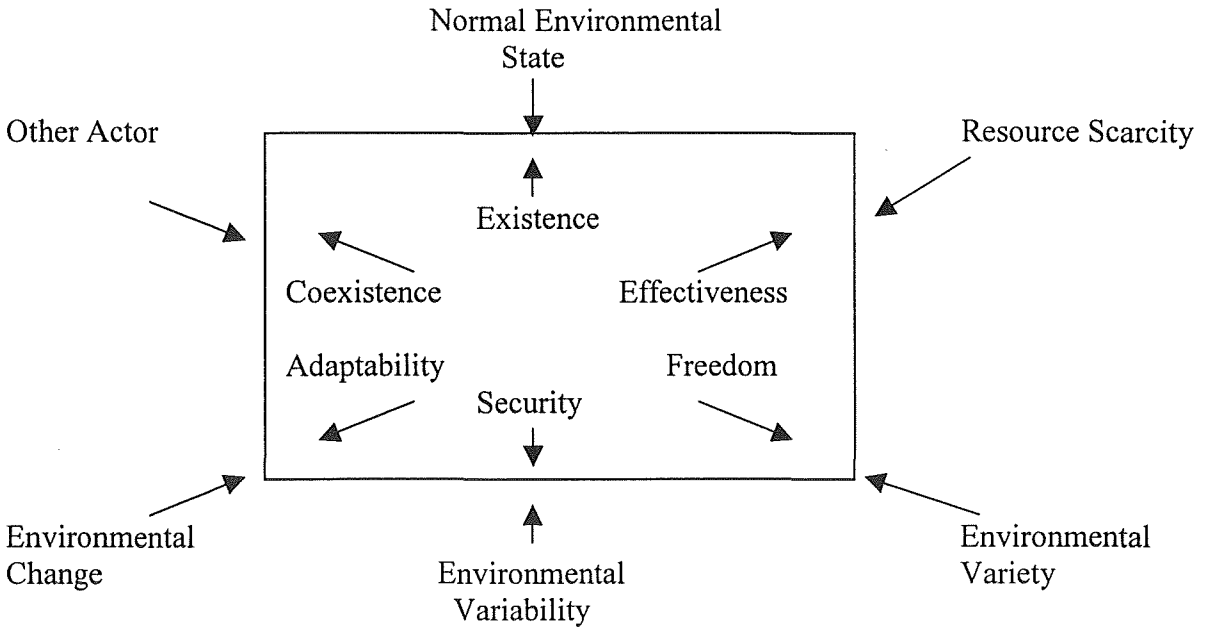


Figure 3.3 Fundamental properties of system environments (external) and their basic orientor counterparts (internal)
Source: Bossel 1999

3.2.4 How to determine the basic needs?

In the aim to investigate the viability and sustainability of each **potential**, from human, support and natural subsystems, and consequently for the whole system, appropriate **indicators** need to be selected for each of the basic **orientors** or basic needs. The indicators are quantitative or qualitative measurements that having being chosen adequately can provide direct or indirect information of the satisfaction of the basic needs of the system, and therefore of its sustainability.

A recursive way, suggested by Bossel, to identify indicators is through appropriate questions by system' orientors, see Table 3.1. These questions have to be made for every component subsystem, since the author suggests that in a complex system, attention to *all* subsystems and

the total system is essential for finding reliable indicators and making decisions regarding its sustainability (Bossel, 1999).

Table 3.1 Recursive scheme for identifying indicators
Source: Bossel, 1999

Orientor	Related question
Existence	Is the system compatible with and able to exist in its particular environment?
Effectiveness	Is it effective and efficient?
Freedom of Action	Does it have the necessary freedom to respond and react as needed?
Security	Is it secure, safe and stable?
Adaptability	Can it adapt to new challenges?
Coexistence	Is it compatible with interacting subsystems?
Psychological needs	Is it compatible with psychological needs and culture?

Once the set of indicators for a system is determined and its information is available, the next step is finding out the greater deficiencies or the weakest points of the system. In other words, it is to find out where the basic needs or **orientors** are not being satisfied and the **potential's** viability and sustainability is being threatened.

3.3 Sustainability Indicators for Colombia

Using Bossel's framework, sustainability indicators will be defined for the system of Colombia. The purpose is to inspect the critical elements that affect the sustainability of the country and all of its subsystems, society, government, economy, infrastructure, and environment. Special attention will be placed in the role of water resources for sustainable living of Colombian People.

The set of indicators identified for every subsystem will be presented by orientor categories in chapter four. Some indicators will be described further by presenting actual information and trends. The analysis of sustainability for Colombia will be based on information gathered

through the indicators; that is the subject of chapter five where conceptual models will be explored to gain a better understanding of the Colombian situation.

3.4 The role of water in the sustainability of Colombia's systems

The use of resources is involved in the interaction between the subsystems and that is expected to appear or be reflected in the set of indicators obtained. For example water is expected to be involved in indicators that show food production, health, basic public services, etc, linking the human and natural systems through the infrastructure systems.

Therefore, analysis of the conceptual model proposed for the natural sub-system, and its relationships with the other system's elements, will allow us to locate the key aspects of water use and its role in the sustainable living of Colombians. Further, this will enable us to suggest appropriate recommendations in the areas where unsustainabilities are found.

Chapter 4: Sustainability Indicators for Colombia

In this chapter, the sustainability indicators defined for Colombia, applying Bossel's framework, are presented and expanded. Colombia is considered the total system, from which three subsystems, human, support and natural are studied. First, the whole set of indicators from the application of the methodology itself is outlined. Then the specific criteria utilised for narrowing down the indicators are brought up, and the information collected for each of the selected indicators is expanded. In addition, the methodology is examined in the practical sense and some difficulties encountered are mentioned.

4.1 Applying Bossel's framework

Once the system is defined, Bossel's methodology is very clear and straightforward. In addition to the question scheme suggested in the last chapter (Table 3.1) for defining indicators, a comprehensive number of indicators suggested by Bossel for a global region were used (1999:91-106). Furthermore, examples developed for New Zealand and for the state of Upper Austria also mentioned in Bossel's material (1999) were consulted. All tools and examples were used analytically in an attempt to place them in the context of Colombia.

4.1.1 Developing Sustainability Indicators for Colombia

The preliminary set of sustainability indicators that came out of Bossel's analysis is shown in Table 4.1. The indicators are presented by orientor categories for each subsystem and more than one indicator is suggested for each orientor. Also, for each subsystem there are two classes corresponding to two levels of analysis: the subsystem performance and the contribution to the total system.

According to Bossel, ideally indicators should initially be developed without reference to available data sets (1999); thus to begin with every indicator is formulated by thinking of its usefulness to illustrate whether the orientor or basic need is being satisfied for the system of Colombia.

Table 4.1 Preliminary set of sustainability Indicators for Colombia

ORIENTOR	HUMAN SUBSYSTEM		SUPPORT SUBSYSTEM		NATURAL SUBSYSTEM	
	Subsystem Performance	Contribution to the total system	Subsystem Performance	Contribution to the total system	Subsystem Performance	Contribution to the total system
Existence	Poverty Net population growth rate	Infant Mortality Rate Life Expectancy at birth	Net growth of built capital (infrastructure and economy) Rate of change of per capita service capacity (roads, schools, hospitals)	Percent of people with inadequate access to basic public services Percent of individual lifetime required to secure means for sufficient lifestyle	Loss of agricultural land and forest (and its change rate) Depletable resources lifetime	Percent of carrying capacity used at current lifestyle Investment and expenditure in resource extraction and in waste clean up
Effectiveness	Share of population affected by unsolved social problems Percent of people covered by any Social Security System	People with unsatisfied basic needs	Hours of paid work required to meet basic needs at actual minimum wage	Percentage of GDP of "goods" (excluding the "bads"), such as looking at Genuine Progress Indicators GPI if available)	Resource throughput per capita (energy/cap-year) Greenhouse gases emissions per economic output (eg CO2/$GDP)	Solid waste generated and recycled Renewable fraction of total materials and energy resource use
Freedom of Action	Unemployment Rate (and the rate of change of it) Housing affordability	Informal sector, growth rate or population living out of (size of informal sector)	Fraction of infrastructure capital controlled by overseas interest	Decisions taken by own government (fraction national policies that are actually not international imposed)	Fraction of area in native forest Buffer capacity of reserves vs. utilised	Dependence of jobs on natural resources Fraction of land under sustainable management
Security	Crime Rate Frequency of violations of basic Human Rights	Number of victims of the Civil Conflict (dead and displaced people)	Energy productivity Investment rate in Health/Investment in Defence (Army etc)	Rate of change of ecological footprint Rate of change of regional carrying capacity	Ecological footprint /sustainable footprint Accumulation of persistent pollution (rate of production or import of key chemicals/rate of absorption)	Depletion rate and lifetime for non-renewables Percent dependence of vital supplies on sources not under regional control

Adaptability	Dependency Ratio Adult literacy rate	Percent of people with access to education Percentage of Grassroots NGO's or NGO's with funding	National or regional research activities (R & D Institutes) Investment rate in Education /Investment rate in production capita	Qualifications required in labour market Rate of change quality lifetime (education, health care , transport, communication Level of bureaucracy (bureaucrats per working adult)	Rate of development renewables relative to depletion of nonrenewables Percent of local adaptations of resources use methods to local conditions	Ability of essential infrastructure to shift to alternative resource base Percent of unpolluted streams & beaches (km)
Coexistence	Income distribution (ratio of top to bottom incomes)	Quality of life of Indigenous communities (poverty?, resources?)	Non renewable resource consumption per capita	Ecological footprint/sustainable footprint	Rate of change in area of intact ecosystems Rate of change in ecological diversity index	Fraction of resource use dependent on international commons – atmosphere etc Investment in Environment, forestry, agriculture as fraction national income
Psychological needs	Alcohol, tobacco and drug consumption Lifetime fraction available for leisure	Violent deaths in the streets Fairness level (percent of population seeing the system as extremely unfair) Percent of population who rather live elsewhere for reasons of individual development	Percentage of public facilities that are being privatised	Percent of people that can afford private services (health and education) Percent of population under stress related with infrastructure problems (transport, communication, etc.)	Fraction of population under cooperative principles Accessibility of outdoors to city dwellers (tourism)	Level of anxiety/concern about resources environment & future Want to move elsewhere for children's future

4.2 Determining the scope of the indicators

After formulation of the whole set of indicators the subsequent task is to go through them and select those that can be expanded and could contribute to further analysis. The criteria used for this selection of the indicators are shown below. The implications derived from the application of the specific criteria and the difficulties encountered when applying the methodology are then discussed.

4.2.1 Criteria for the selection of indicators

There are four main decisive factors restricting the selection of indicators for Colombia. These are stated below.

4.2.1.1 Availability of information

Bossel's book (1999) suggests a number of indicators for which information is difficult to find or is not collected or reported as such. Some of these indicators apply in the case of Colombia, but it is not possible to include them due to their unavailability. Good examples of indicators which cannot be followed up are: the 'level of institutional bureaucracy (bureaucrats per working adult)' defined in the support subsystem for the adaptability orientor. The 'fairness level (percent of population seeing the (socio-economic) system as extremely unfair)' and also the 'percent of population who would rather live elsewhere for reasons of individual development' defined in the human subsystem for the psychological needs orientor. In addition, the 'percent of local adaptations of resource use to local conditions' defined in the natural subsystem in the adaptability orientor. These indicators would provide a valuable illustration of Colombia's state concerning a sustainable living for its people, but they cannot be evaluated.

4.2.1.2 Recurrence

As it was stated earlier in the methodology chapter, all subsystems are interrelated and the division made among them is just a simplification for the study of a complex system. As a consequence, some indicators are found to be useful at the same time for different orientors for different subsystems. For instance, the ecological footprint and its relation to a sustainable footprint, as a measure of carrying capacity, is defined for the coexistence

orientor in the support subsystem as well as for the security and existence orientors in the natural subsystem. In this case the indicator is selected, since its information is available, to describe the support system, because it is believed that analysis of carrying capacity shows the links between the human and natural systems, done through the support system.

4.2.1.3 Inter-connectiveness

There are indicators defined for the same subsystem that are very closely interconnected. For instance, in the natural subsystem, 'depletable resources lifetime' for the existence orientor and 'rate of development of renewable versus depletion of non-renewable resources' for the adaptability orientor, are strongly interrelated. One represents the stock variable and the other is the rate of change or flow variable for the same feature. In this case, although both indicators should be included because they are necessary to represent the situation for a country rich in resources as Colombia, their information is not easy to find or it is not measured yet, so they are excluded from the set.

4.2.1.4 Specificity

Some indicators are specified as index, percentages and/or fractions, and for some of these the information is found in the statistics or other sources in these formats. However, in some cases the available information is not the most appropriate. For example, for the indicator 'endangered species' in the natural subsystem, the percentage of endangered species in Colombia is not available in the sources consulted but the number of them by categories is. In this case, the available information is used instead of discarding a valuable indicator.

Furthermore, there are some other indicators that are not specified in these formats (index, etc); their information is harder to find, and therefore they have to be exemplified in an analogous way. An example of this is 'housing affordability' which is defined for the freedom of action orientor in the human subsystem. The closest information available with respect to this matter is 'distribution of housing ownership', which is presented in percentages.

In addition, for those indicators with no precise available information as index or percentages, other relevant and illustrative information is chosen to describe them. For

instance, for the security orientor of the natural subsystem in Colombia the indicator 'Consequences of climate variability' was proposed and the El Nino phenomenon was selected. Nevertheless, there is not a specific and available index showing the impact and consequences of this phenomenon. Hence, for this case the account of the consequences, physical and material damage, deaths toll and costs involved in the reconstruction of affected areas is used to describe this indicator.

The application of these four criteria filters the preliminary set of indicators and leads us to a more limited set. This is shown in Table 4.2. These indicators are expanded in the next section of this chapter and will serve as illustrations about the sustainability or unsustainability of the country.

Table 4.2 Selected set of sustainability indicators for Colombia

Orientors' categories	Human Subsystem	Support Subsystem	Natural Subsystem
Existence	Population growth rate	Percent of people without access to basic public services	Loss of agriculture land and forests
	Poverty		
	Life Expectancy		
Effectiveness	Unsatisfied basic- needs	Hours of paid work required to meet basic needs at actual minimum wage	Greenhouse gas emissions per economic output
	Social security		
Freedom of Action	Unemployment rate	Percent of population living in cities	Fraction in native forest
	Informal sector		
	Housing affordability		
Security	Victims of the armed-conflict	Energy productivity	Consequences of the climate variability: El Niño phenomenon
	Crime Rate		
Adaptability	Adult literacy rate	Investment rate in Education	Unpolluted waterways
	Access to education		
	Dependency ratio		
Coexistence	Quality of life of indigenous- communities	Ecological footprint vs. sustainable footprint	Endangered species
	Income distribution		
Psychological needs	Alcohol, tobacco and drug- consumption	Migration patterns	Level of concern about resources and environment
	Lifetime fraction available for- leisure		

4.2.2 Some implications of the criteria used

Before going into elaboration of the selected indicators, it is important to mention two important implications of the particular criteria used and the selection process for the system of Colombia. These are:

- Only one person made the evaluation and determined the indicators set, and therefore it is subjective. Bossel asserts that the best way to develop a comprehensive list of indicators is by working in teams and "in practice, it [the indicators list] should be the outcome of a much more representative process and be subject to peer and community review" (1999; 93). Peet also emphasises the importance of the so-called stakeholder involvement, in which the viewpoint of the community and its participation in policy-making and decision-making is essential (1999). Therefore, ideally the set of indicators proposed here should be discussed further with more community groups, government representatives, Colombian scientists and anyone interested in the country.

- There are only a few indicators considered. The preliminary set contained up to 72 indicators but the final set only includes 31. Bossel recommends more than one indicator for each orientor, however this is the case here primarily due to unavailability of information. Even the subdivision between indicators that shows the subsystem performance or the contribution to the total system has to be missed because there is not sufficient information (this is why Table 4.2 has only one column per every subsystem instead of two as shown in Table 4.1). Thus, the important point is that all chosen indicators are believed to provide the essential information required for the sustainability analysis.

4.3 Elaborating the selected set of indicators

In this section all indicators selected are expanded. The information regarding the facts and trends of every indicator is discussed with figures and examples. The main sourcers of information were the Colombian National Statistics Department (DANE) and other Colombian institutes together with international databases of the institutions like The

World Bank and The United Nations. The indicators are presented by subsystems and by orientors' categories.

4.3.1 Human subsystem

4.3.1.1 Existence

The question here is whether the human subsystem of Colombia can exist in its environment. The indicators selected are Population Growth Rate, Poverty, and Life Expectancy.

4.3.1.1.1 Population Growth Rate

Colombia's population is projected to be 42,299,301 by the end of the year 2000 according to the projection of the Colombian National Statistics Department, DANE, (2000). The last census was carried out in 1993, when the total population was 35,886,280[4] and the population growth rate was 2.2%. The annual population growth rate has been decreasing the last four decades, and from 1995 and 2000 it is estimated to be 1.87% on average per annum (United Nations, 2000).

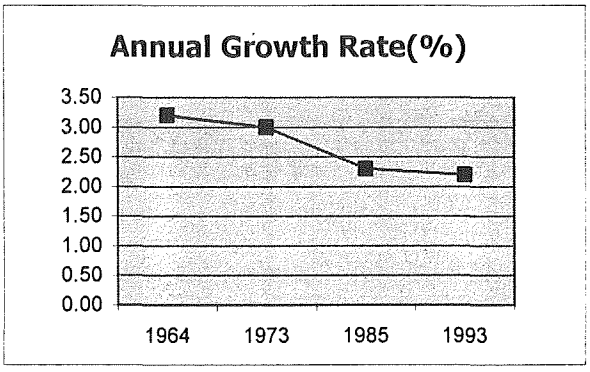


Figure 4.1 Population growth rate in Colombia from Census Returns (1964-1993)
Source: DANE, 2000

[4] There is notorious disagreement about the figures for the total Colombian population for the last census, 1993. The national statistics authority source, DANE, in some places in their web page states the figure of 33,109,840 whereas in other places it presents 37,664,711. Moreover, the World Bank and the World Resources Institute, WRI, have different numbers and projections. Here an average figure of 35,886,280 has been taken, which also has been used in other studies (Parra, 1999)

The reduction of population growth in Colombia in the last 40 years is associated with reductions in the birth rate, mainly, due to improvements in women's work participation and contraception use. Moreover, a demographic evaluation of population policies carried out in 1980 found that the remarkable reduction of general fertility in Colombia between the 1960's and 1980's was attributed 44.1% to formal family planning programs, 34.6% to other factors and 21.3% to socio - economic factors (United Nations, 1983).

However, Colombia's population places the country as one the 30 most populated countries in the world in 1998 (United Nations, 1998). An increase of almost 11 million people is expected in the next 15 years as a consequence of the trends in growth rate and the population momentum (DANE, 2000). This increment of population poses a challenge for the government in order to provide sufficient social and health services and employment opportunities, since Colombia's fertility transition indicates an increase of working age population and elderly in the next 15 years.

4.3.1.1.2 Population under the poverty line

Poverty could be measured based on the daily income that a person spends in food for survival; this is defined as a "Poverty Line." Internationally the Poverty Line has been expressed in dollar value, as 1 US dollar per day, which is equivalent to approximately 2,000 pesos (Colombian currency). However, in Colombia the Poverty Line is defined at 52,000 pesos per month (El Tiempo, 1999), around 1,730 pesos a day (less than one dollar).

In Colombia if a person receives less than 52,000 pesos per month they are not able to live in dignity and this condition is called "Misery". If a person has an income higher than 52,000 and lower than 120,000 pesos, that is considered "Poverty", which means that he/she does not have enough to live on (El Tiempo, 1999).

According to the information from the National Planning Department, presented in the main newspaper of Colombia, El Tiempo (1999) currently 55% of Colombia's population lives in poverty, which means that 20 million Colombians earn less than 120,000 per month. The situation is worse in the countryside, where 80% of the people, approximately 7 million, are poor. Furthermore, the same study shows that 21% of the population lives in

misery and again the situation in the country-side is worse where 46% of the people have a income lower than 52,000 pesos a month.

The economic crisis together with intensification of the armed conflict of recent years has contributed to the increase of poverty and misery in Colombia. Although the Latin-American authorities claim a reduction of poverty of 2% during the 90's in the subcontinent (CEPAL[5], in El Tiempo, 1999) the absolute number of poor people continues rising and in any case Colombia is among the countries in the region where poverty is continuously increasing.

Further, the international statistics of the World Bank, WB, and World Resources Institute, WRI, show lower figures than national statistics. From WRI figures it appears that the poverty in Colombia was only 7.4% compared with 16% according to DANE in 1991; in 1996 the WB gave 11% compared with 27 % from DANE. Differences in the value of the Poverty Line explain such differences in poverty figures. The value of one dollar in Colombia is very little money so its purchasing power is very limited. What is called international Poverty Line could be called in Colombia the Misery Line (one dollar a day). This situation and the increment of poverty can be appreciated in the data of the Table 4.3.

Table 4.3 Comparison of Poverty Data in Colombia
Source: National statistics: DANE, 2000 (for years 1991 and 1997). El Tiempo, 1999 (for year 1997). International statistics: World Bank, 2000 (for year 1996) & World Resources Institute, 1999 (for year 1991).

Source	Year	People below Poverty Line %
Nationals Statistics	1991	16
	1997	27
	1999	55
International Poverty Line	1991*	7.4
	1996*	11
	1996**	28.7

Notes: * corresponds to less than $1 dollar a day
** Corresponds to less than $2 dollars a day

[5] CEPAL, United Nations Economic Commission for Latin America

4.3.1.1.3 Life Expectancy

The Life Expectancy, LE, in Colombia shows a similar increasing trend as to the rest of the world. In the late 1960s LE was 60 years (combined males and females) and it has been estimated to be 70.9 years for the period 1995-2000 (WRI, 1999). The increase in LE is attributed mainly to improvements in health services and diseases prevention and treatment. Also the reduction of Infant Mortality contributes to longer life expectancy.

Colombian females have higher life expectancy than males as is the normal pattern in the World; however, due to the particular mortality causes in Colombia, the male death rate is considerably higher than that of females, especially in the age group between 20 and 30. In Colombia the main cause of mortality is Violence; the country has been subject to armed conflict since the 1950s, and political and civil instability have created numerous victims.

DANE has information on the cause and number of deaths for the year 1996, which has been calculated in terms of percentages as follows in Table 4.4:

Table 4.4 Main Causes of Mortality in Colombia in 1996
Source: DANE, 2000

Category (10 main death causes)	Percentage of total deaths	Males percentage for death category	Females percentage for death category
Attack with fire arms and explosives	12	93	7
Acute myocardia infarction	10.9	55.5	44.5
Other Causes (natural deaths not certified by a doctor)	4.5	53.4	46.6
Respiratory chronic obstruction	3.1	56	44
Cardiac Insufficiency	3.1	48.8	51.2
Diabetes Mellitus	2.7	41.6	58.4
Traffic accident	2.4	80.7	19.3
Cerebrovascular disease	2.3	46.2	53.8
Stomach Cancer	2.3	58.8	41.2

4.3.1.2 Effectiveness

Is the system effective and efficient regarding the needs of the population? For this category indicators referred to the social security system and people with unsatisfied needs are studied.

4.3.1.2.1 Unsatisfied Basic Needs

Examining Unsatisfied Basic Needs, UBN, is another common method for measuring poverty in Colombia. The UBN is the combination of at five simple indicators that express the lack of basic commodity's consumption and the low capacity to generate income in the household (DANE, 2000). The indicators included are:

- Households with inappropriate housing
- Households without basic services (drinking water and sanitation)
- Households with high people's density (more than three people per room)
- Households with high economical dependency (more than three dependents for one worker head of household)
- Households with low school attendance (household at least with one child between 7 and 11 without going to school

The individual and aggregate data of the UBN percentage for Colombia is shown in Table 4.5, these figures are developed by the National Planning Department, DNP, in Colombia. The UBN percentage in the country was decreasing until 1997, where it starts slightly to increase. This assertion agrees with other most recent measurements of poverty discussed here earlier. Individually, within the indicators that integrate the UBN, there are dissimilar tendencies; whereas the percentage of people without access to basic services decreased notably, the percentage of people with a crowded household did not decrease that much over the 13-year period presented. Households with low school attendance, in percentage, are less in 1998 than in 1985. However, households with inappropriate housing conditions and high economical dependency, although less in percentage, still have not improved significantly in these years taking into account a growth in the population of about ten millions in the same period (Parra, 1999).

Table 4.5 Colombian Figures in UBN
Source: National Planing Department, 2000

% Population under UBN by indicator	1985	1993	1997	1998
Unsatisfied Basic Needs, UBN	45.60	37.20	25.40	25.90
Low School Attendance	11.50	8.02	4.11	4.50
High People' s Density in the household	19.40	15.40	11.25	11.20
Without Basic Services	21.80	10.52	4.76	5.00
Inappropriate Housing Conditions	13.80	11.60	7.71	7.30
High Economical Dependency	15.90	12.83	8.97	9.50

4.3.1.2.2 Social Security

The coverage of social security in Colombia is very limited. According to the World Bank (1995), in 1987 only 30% of the economic active population were covered by social security. In 1997, according to DANE (2000), 42.81% of the total population was not affiliated to any social security health system, being 39.06% in urban areas and 52.51% in rural areas. There are significant differences within regions in the country regarding social security. For example, in the countryside of the Atlántica Region the people not covered by the social security system reaches 73.22%; whereas in the cities it could be as low as 28.77%, as in the case of Medellín, the second biggest city of Colombia (DANE, 2000).

4.3.1.3 Freedom of Action

The question to be answered here is do the people in Colombia have necessary freedom to respond and react as needed? Indicators that can illustrate this are the unemployment rate, the magnitude of the informal sector and housing affordability, all being variables very closely interrelated, especially the first two.

4.3.1.3.1 Unemployment rate

Unemployment in Colombia shows a recent growth trend, which is a matter for concern. 1999 was declared a year of economic emergency, since unemployment exceeded 20%. The economic recession of the late 90s in the whole subcontinent has affected Colombia severely. The situation is worst in the countryside and among the poor people. In the poorest 10% unemployment reaches 61% (El Tiempo, 1999). Unemployment figures for the last 20 years are presented in Table 4.6.

Table 4.6 Unemployment in Colombia, last 20 years
Source: Parra, 1998 (for data of 1980 and 1985) rest of data from DANE, 2000

Year	Unemployment Rate (%)
1980	9.7
1985	13.8
1990	10.2
1992	9.2
1994	7.6
1995	8.7
1996	12.0
1997	12.1
1998	15.0
1999	20.1
2000	20.2 *

Note: Survey done for the 7 main cities of Colombia: Santafé de Bogotá, Medellín, Cali, Barranquilla, Bucaramanga, Manizales and Pasto.
* Preliminary figures for March

4.3.1.3.2 Informal Sector

Informal employment is a significant and growing sector of the economy in Colombia as well as in other developing countries. Various characteristics contribute to this problem. Basically, the absorbing capacity of the industrial and services sector in urban areas has not been enough for the surplus of labour. Most of the inhabitants of the city come from the rural areas, where there has been low agricultural employment, landlessness, and even more problems of violence that have pushed large numbers of people to the cities. As a result high levels of unemployment and a substantial informal sector in Colombian cities are common features.

Clearly people who depend on the informal sector for survival do not have any social security and their income might be classified as under the poverty line. Another consequent problem that is becoming significant is underemployment. Some relevant and available data are shown in the Table 4.7.

Table 4.7 Distribution of Labour Force in the 7 Main Cities of Colombia
Source: DANE, 2000. Parra, 1998 (for the data of the informal sector of Bogotá)

Population by categories	1998	2000
Total Population	14,100,000	14,525,000
Economic Active Population (15-60)	6,926,000	7,249,000
Unemployed Population	1,082,000 (15.6%)	1,465,000 (20.2%)
Employed	5,844,000	5,784,000
Underemployed population, (%)	1,180,488 (20.2%)	1,312,968 (22.7%)*
Informal sector (for Santafé de Bogotá in 1993)	54%	
Informal sector (Population for 10 cities in Colombia)	3,531,202	

Note: *Percentage for 1999. The rest of the data for 2000 is preliminary.

4.3.1.3.3 Housing Affordability

Table 4.8 Distribution of Housing Ownership in Colombia, 1997
Source: DANE, 2000

	Type of Housing Ownership(%)		
	Own	Tenancy	Other
Total national	55.27	35.90	8.83
Non poor	55.87	36.09	8.03
Poor	51.17	34.59	14.25
Santafé de Bogotá	50.51	43.54	5.95
Non poor	52.40	42.72	4.88
Poor	34.12	50.72	15.16

Note: These figures refer only to households in the urban areas.

The information in Table 4.8 shows that nearly half of Colombian people living in urban centres can afford their own house. It is interesting to see that there is not much difference between housing for what is considered poor or non-poor (perhaps excluding only high-income groups). The Colombian middle class and poor both face lack of housing opportunities. A slightly notorious difference is seen with the poor urban dwellers of Santafé de Bogotá, where just 34% of households own their house. Moreover, among the urban poor other forms of ownership are more common, such as illegality and squatters.

In the case of Bogotá, the supply of housing for the inhabitants and immigrants of the city has been limited. The only affordable places for poor dwellers have been the outskirts.

The reasons are related to the prices of land. The native Bogotans and higher income groups have occupied the interior of the city. Therefore, middle income and low-income families are usually located in the neighbourhoods at the edges of the city. The problem with the outskirts of the city is the unsuitability of the land for urbanisation. However, these areas become urban due to the illegal urbanisers, called in Colombia 'Piratas' who are unscrupulous housing and plot sellers that at lower prices offer inadequate land and accommodation without the required licence. In this way the high slope hills of the southeast and north east of the city, the borders of the rivers and creeks and the filled swamps have been and continue to be urbanised.

4.3.1.4 Security

Is Colombia secure, safe and stable for its inhabitants? The straight answer to this question is no. Colombia has faced a long and deep-rooted political conflict for more than 40 years. There are various armed groups in the country permanently fighting each other. Guerrilla movements, paramilitaries and the Colombian Army all impose a real threat for civilians. Rural communities have been the most affected by the conflict; however, cities face extensive vandalism and crime. Further, the condition has been disturbed by drug cartels. Victims of the armed conflict and crime rate are the selected indicators.

4. 3.1.4.1 Victims of the Armed Conflict

According to the main right wing Colombian newspaper, El Tiempo, it is estimated that in 1999 there were 2,000 kidnapped people, 3,000 civilians killed in the cross fire, 2,000 victims of massacres and 400,000 displaced people due to the armed conflict. All kinds of violations to human rights happen regularly in Colombia due to the armed conflict, in the form of terrorist actions, rural and urban attacks and massacres.

The number of displaced people in Colombia between 1995 and 1999 is close to 1 million and from the year that data started to be collected, 1985, the total is 1,700,000 Colombians. In 1998, 47% of the cases were accredited to the paramilitaries, 35% to the guerrillas and 8% to the Colombian Military Forces. The municipalities affected during the last 4 years represent 39% with respect to the whole territory (El Tiempo, 1999). Areas of displacement are characterised by conflict over the ownership of land, the new colonisation frontiers, drug trafficking and new commercial agricultural enclaves.

Most displaced people migrate to the urban centres. Bogotá, Bucaramanga, Medellín and Barranquilla are the major receiving cities. Since the people are forced to leave their homes they arrive in misery in the cities and are forced to dwell in and invade inadequate and high-risk areas. During 1998, 46% of displaced people were peasants, who owned land and the statistics show that only 13% could afford a new house (El Tiempo, 1999).

According to Observatorio de los Derechos Humanos en Colombia[6], ODHC (2000) violence is the main problem in Colombian society. Along with the loss of numerous lives, the economic cost of the conflict is high regarding physical and natural capital losses. It is estimated that nearly 1,700,000 hectares of agricultural land, since 1990, are no longer productive due to rural displacement (El Tiempo, 1999). Further, in terms of GDP the armed conflict causes with a reduction of between 1% and 1.5% of total GDP annually (ODHC, 2000). However, beyond the economic cost of the war, the social consequences are worse. The resulting insecurity and uncertainty have undermined the basis of social cohesion. Colombian people live permanently with fear.

4.3.1.4.2 Crime Rate

Overall the crime rate in Latin American cities is very high. Around 110,000 people are killed annually in the subcontinent and for every person killed there may be between 10 and 15 people injured according to Pan-American Health Organisation, OPS, (El Tiempo, 1999). In 1997 in the country it was estimated that there are around 26,000 homicides per year, that is 70 per 100,000 people (OPS, in ODHC, 2000). These figures place Colombia as one of the most violent countries in the world; the homicide rate is four times the average for Latin-America, sixteen times the one for Europe and seventy times the one for Asia (OPS, in ODHC, 2000).

Consequently, Santafé de Bogotá is a highly violent city, in 1998 there were 82 murders per 100,000 people (WRI, 1999). Frequent armed robberies and assaults occur in the city; in the poorest and most violent neighbourhoods there are several 'pandillas', groups of young delinquents who also operate in other places. The lack of formal employment and

[6] Observatory of Human Rights in Colombia

education, and also psychological factors, such as displacement due to rural violence and harsh economic conditions, contribute to the problem of insecurity in the cities.

4.3.1.5 Adaptability

The adaptability category is the study of the abilities of the human sub-system to adapt to new or permanent challenges. The education of society is a major factor; illiteracy and access to education are taken into consideration in this section. The proportion of young adults to the inactive population (children and elderly) is another variable explored here.

4.3.1.5.1 Adult Literacy Rate

The illiteracy rate in Colombia has reduced considerably. In 25 years it has dropped 10% in a situation of a population increase of almost 20 million. In 1973 it was 19% and 9% in 1998 (World Bank, 1995 and 2000). There is no significant difference between figures for adult males and females in recent years. Interestingly it has been projected that by 2015 female illiteracy will be lower than male in contrast to the trend of 30 years ago. The data can be seen in Figure 4.2.

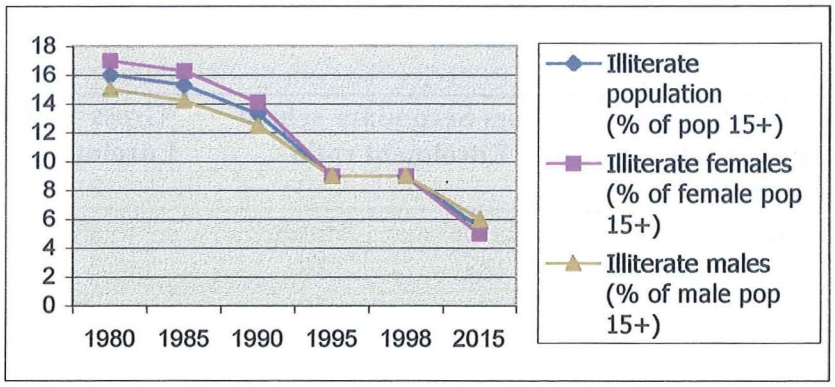


Figure 4.2 Adult Illiteracy in Colombia
Source: World Bank, 1995 and 2000 (for all data up to 1998)
WRI, 2000 (for projection of 2015)

4.3.1.5.2 Access to education (primary, secondary and tertiary)

Along with the improvement in adult literacy, illiteracy in the young has also been reduced. In 1998 only 4% of males and 3% of females between 15 and 24 were illiterate (World Bank, 2000). However, the statistics of people who remain in the education system

are not as high as for the ones who begin primary education. The supporting data can be seen in Table 9.

Table 4.9 Primary Education Efficiency in Colombia[7]
Source: World Bank, 2000 and WRI, 1999 (only for the data of 1994-1995)

Year	Percentage of Cohort Reaching Grade 5*			Children Out of School (thousands)	
	Total	Females	Males	Primary	Secondary
1980		39	36	992	1,781
1994-1995	58				
1996				471	1,180
1997		76	70		

Note: Percentage of cohort reaching grade 5 is defined as the share of children enrolled in the first grade of primary school who eventually reach grade 5.

The number of children out of school has declined in the last twenty years nevertheless, it continues to be considerable and even more for secondary education. Table 4.9 shows that still more than 1 million school-age children were not attending secondary school in 1996. These findings also agree with the figures of school enrolment presented in Table 4.10

Table 4.10 Education Enrolment in Colombia
Source: and World Bank, 1995 and WRI, 1999 (for the data of 1995-1996)

Year	Gross Primary school Enrolment ratio		Gross Secondary school Enrolment ratio		Gross Tertiary Enrolment ratio
	Female	Males	Female	Males	Total
1965	86	83	16	18	3
1980	120	117	42	40	10.2
1989	110	109			13.7
1991			60	51	
1992	117	116			
1993					9.9
1995–1996	114	115	72	62	

Note: Gross enrolment ratio is defined as the percentage of students of all ages at the primary, secondary or tertiary level with respect to school-age children. The gross enrolment ratios may exceed 100% because some pupils are younger or older than the standard primary school age

[7] In Colombia primary education comprises 5 grades; nevertheless, education starts at Grade 0, which is pre-primary school

There is a small difference between female and male school enrolment in secondary as well as primary, female enrolment being higher. However, this difference is becoming more accentuated in recent years for secondary school. This characteristic is due basically to the need for male children to start working at an early stage in order to help their families economically; obliging them to quit school. Moreover, for the poor sector of society, education is more difficult to afford. 20 out of 100 poor children cannot go to school (El Tiempo, 1999), and as a consequence of the increased rate of poverty since 1995-96 a decrease in school attendance would be expected.

Tertiary education has had much lower participation; the increase in the enrolment ratio figures since the 1980s is almost negligible and even more it started to decline from 1990. Public universities lost their public character since early 1990s due to the structural adjustment reforms (privatisation being the most significant), hence tertiary education became more difficult for Colombians to afford.

4.3.1.5.3 Dependency Ratio

Colombia is undergoing demographic changes as a result of the fertility transition. The young population is decreasing in proportion to adults and elderly, the adult population increasing most significantly. As a result the Dependency Ratio, DR, defined as the relation of dependent population (below 15 and above 64) to the working-age population (between 15-65), shows a decline trend, as appears in Figure 3. In 1996 it was around 1 and in 1998 is estimated to be 0.6.

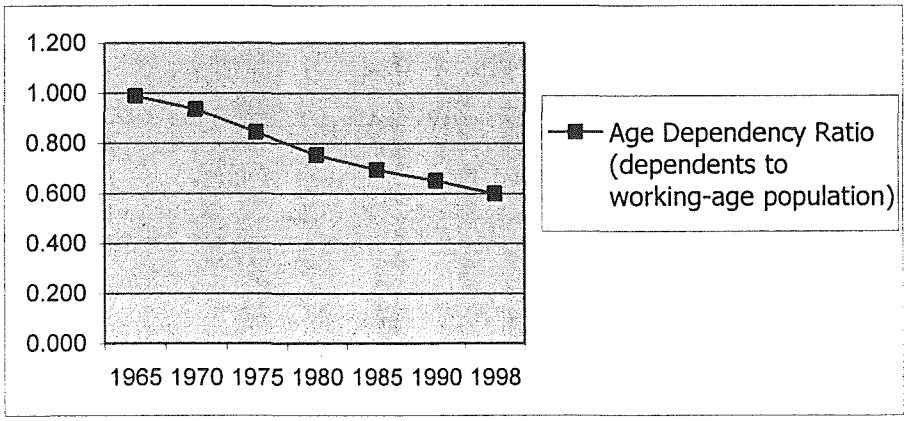


Figure 4.3 Age Dependency Ration in Colombia
Source: World Bank, 1995 and 2000.

This declining trend of the DR could be interpreted as positive, because fewer dependents in relation with the working population mean better functioning for the social security system and for the economy in general. However, these statistics do not take into consideration the actual active population among the working-age population. The higher unemployment in Colombia and its rising tendency over the last 5 years directly affect the DR and consequently what is derived from it in the economy and social sector. Moreover if disabled and sick people in the age group between 15 and 65 are also considered as dependents, the DR could be even higher.

4.3.1.6 Coexistence

The Coexistence category deals with the ability of the population to be compatible with other interacting sub-systems. The Colombian population is composed of various diverse groups in terms of ethnicity, beliefs, political affiliation and income. These differences cause the human-sub-system to face challenges of sustainability. Quality of life of indigenous communities and Income distribution are the indicators explored for this orientor.

4.3.1.6.1 Quality of Life of Indigenous Communities

Although the indigenous population accounts for only 3% of the total Colombian population, in 1994 there were 1,106,499 indigenous people (DANE, 2000). There are approximately 80 ethnic groups living in Colombian territory, mainly in the east or Pacific region (Departments of Chocó, Cauca and Nariño), and in the south and south-west regions of the country, Amazonia and Orinoquia (Departments of Vichada, Arauca, Guania, Guaviare, Putumayo, Amazonas). There are some few others in the north in La Sierra Nevada de Santa Marta. They live mostly in the areas of tropical rain forest, the jungle, and in the mountains of the Andes. The main indigenous groups and their population are shown in Table 4.11.

Table 4.11 Indigenous Groups in Colombia
Source: DANE, 2000

Ethnic Group	Population
Arhuaco	11,047
Awa Kwaiquer	11,327
Cañamomo	11,964
Coyaima	10,308
Embera	50,430
Guambiano	13,964
Inga	12,312
Nasa (Páez)	96,165
Quillansinga	45,601
Senú	38,736
Sikuani	20,462
Wayuu	93,882
Yanacona	17,708

The native indigenous population of Colombia was reduced drastically in times of colonisation, between 1500 and the 1800s and as a result some ethnic groups became extinct. The remaining indigenous population was forced to migrate and live in more remote areas of the deep jungle far away from the urban 'western' settlements funded by Spanish colonisers. It is only till 50 years ago that the population of indigenous people started to increase after 500 years of decline.

There are no separate statistics available for the indigenous groups in terms of quality of life. Most of the communities continue to face problems of colonisation, the process of 'westernisation' and degradation of their environment for industrial and commercial activities in the forests. These problems represent a real threat to their quality of life, which is supported in their relation with the land.

The Negro communities undergo similar and probably worse situation. Most of the Negro groups, brought to the country from Africa in times of Spanish colonisation, were mixed with the local communities, but still there are some original ethnic communities. They faced similar land problems and even more problems of identity and recognition. Table 4.12 shows the data about Negro communities in Colombia.

Table 4.12 Negro Communities in Colombia
Source: DANE, 2000

Ethnic Group	Population
Cimarrón	1,474
Negro	493,170
Raizal	7,699
Otavaleño	16
Without Information*	71,923

Note: * People who claimed they belong to an ethnicity but did specify which.

Both Indigenous and Negro communities are still minorities with regards to the rest of the population. They have a minor representation in Colombia government; although in the case of indigenous groups they have their own strong organisation systems. The fact that there are still many urban-Colombians who are not aware of these minority communities shows how poor has been the process of recognition and interaction among different Colombian coexistent groups.

4.3.1.6.2 Income Distribution

The inequality of the income distribution in the country can be seen through the Gini Index. The Gini index provides a convenient summary measure of the degree of inequality. Gini Index measures the extent to which the distribution of income among households within an economy deviates from a perfect equal distribution (World Bank, 2000). A Gini Index of zero represents perfect equality, while an Index of 100 implies total inequality. Colombia's Gini Index was 57 in 1996 from World Bank (2000) data and 51 in 1991 from WRI (1999), as shown in Table 13.

Table 4.13 Income Distribution Indicators in Colombia
Source: WRI, 1999 (data for 1991) and World Bank, 2000 (data for 1996)

Year	Gini Index	Percentage Share of Income						
		Lowest 10%	Lowest 20%	Second 20%	Third 20%	Fourth 20%	Highest 20%	Highest 10%
1991	51		3.6	8.8	12.9	20.4	54.4	
1996	57.1	1.1	3.0	6.6	11.1	18.4	60.9	46.1

Notes: Percentage share of income refers to income shares by percentiles (deciles or quintiles) of population ranked by per capita. Percentage shares by quintile may not sum to 100 because of rounding.

Furthermore, the inequality in the distribution of income is reflected in the percentage shares of income accruing to segments of the population ranked by income levels (World Bank, 2000). The segments ranked lowest by personal income receive the smallest share of the total income. Colombia shows a typically unequal income distribution, where the highest 20% of the population account for 60% of the total income and the lowest 20% share only 3% of the total income.

4.3.1.7 Psychological Needs

Does the system satisfy the psychological needs of the population? Indicators in this category should give a sign of the satisfaction of the psychological needs of Colombian people. The consumption of alcohol, tobacco and drugs and the availability of recreation and leisure among Colombians are explored.

4.3.1.7.1 Alcohol, tobacco and drug consumption

In Colombia in 1994 the prevalence in the consumption of alcohol was 25.2%, in the age group above 12 years, and for smoking tobacco was 21.4% according to the World Health Organisation, WHO (2000. The alcohol consumption among young people is higher, 7 out of 10 people between10 and 24 years old have consumed alcohol at least once (Rumbos, 2000).

The consumption of drugs is a large social problem, especially among the young people. With regards to marijuana, the most consumed drug with a prevalence of 9.2%, between 270,000 and 486,000 young people between 10 and 24 years old have consumed it at least once and between 113,000 and 192,000 are currently consuming it. The second most consumed illegal drug is cocaine with a prevalence of 8.8% (Rumbos, 2000).

According to Rumbos (2000), the Government programme to reduce drug consumption, violence is one of the main causes of instability of the Colombian society and as a consequence the root of many social problems and the interrelated alcohol and drug consumption.

4.3.1.7.2 Lifetime fraction available for leisure

Unfortunately there is no available direct data on how many Colombians have access to recreation and how much time they can spend in recreation, sports and leisure. However, indirect data can be used; for example, one the main causes contributing to heart diseases (which is the second cause of mortality in Colombia) is the relative physical inactivity, which accounted for 76.4% for the heart problems in 1994 (WHO, 2000). Moreover there is a slight difference between Life Expectancy, LE, and Healthy Life Expectancy, HLE, for the population, HLE is between 8 and 9 years lower than LE for males as well for females, currently HLE is 62.9 (combined males and females) (WHO, 2000). The lack of a very good health among the Colombian population could have reasons associated with poverty and malnutrition, however it also can be associated with lack of disease prevention and health promotion, in which sports practice and adequate recreation are important factors that are probably missing.

4.3.2 Support Subsystem

4.3.2.1 Existence

In order to study whether the infrastructure and economy systems of the country, the support system, are guaranteeing the existence of its people, the indicator Percent of people without access to the basic public services has been selected.

4.3.2.1.1 Percent of people with access to basic public services

Access to safe drinking water, adequate sanitation and health services are the variables chosen for basic public services. The figures for Colombia for the last 25 years are shown in Table 4.14.

Table 4.14 Percentage of people with access to public services
Source: World Bank, 1995 (for data from 1970 till 1988 and 1997*)
WRI, 1998 (for data of 1990-96); DANE, 2000 (for data of 1997)
ACODAL, 2000 (for data of 1998)

	Percentage of population with access to safe drinking water			Percentage of population with access to adequate sanitation			Percentage of population with access to health services		
Year	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
1970	88	28	63						
1975	86	33	64						
1980									88
1985	100	76	92						
1988									
90-96	97	56	85	97	56	85	86	72	81
1997				98.33	65.55	89.62			
1997*	88			76					
1998	90	64							

The data from Table 4.14 shows that overall there has been an improvement in the percentage of Colombian people with access to basic services in the last 30 years. However, there are some inconsistencies due to interrelated issues that have to be considered when reading and interpreting this data, after taking into consideration the different data sources.

The first issue is the differences between rural and urban. Most unsatisfied needs concerning water and sanitation are in rural areas. This difference, between rural and urban, was higher in the early 70s than it is now, and this coincides with the fact that there is a tendency for fewer people to live in rural areas and for rural poverty to be higher. Colombian population trends can be seen in following Table 4.15. This means that the real numbers of people with access to basic services in rural areas could not be so large (in comparison with the total national), even if the percentage is increasing. This is due to the reduction in rural population.

Another issue, the rapid urbanisation of the country, especially since the1960s, has been a significant phenomenon and it has been caused by migration from the countryside as well as natural growth. Although the figures for water supply and sanitation look better for urban centres, the people who have migrated and continue to migrate from the rural areas,

mainly due to poor economic conditions or violence, do not find adequate satisfaction of their needs such shelter, safe water and sanitation. This finding is supported also by the facts that access to safe water and sanitation seems to have declined in the 90s in the cities.

Table 4.15. Population Trends in Colombia
Source: Parra, 1999. WRI, 1998 (for data 1998).

Year	Population	Degree of Urbanisation (%)	Urban Population	Rural Population
1951	11,548,172	38.7	4,469,142	7,079,030
1964	17,484,508	52	9,091,944	8,392,564
1973	22,862,118	59.3	13,557,235	9,304,883
1985	30,062,200	65.3	19,630,616	10,431,584
1993	35,886,280	72.9	26,161,098	9,725,182
1998	41,000,000	73	29,930,000	11,070,000

In the case of Santafé de Bogotá, the capital city, the figures for water supply and sanitation reported are 99% of households connected to the services (WRI, 1998). Nevertheless, this figure comprises only what the water authority calls urban perimeter, which is land under 2,800 meters above sea level (m.a.s.l.) The city is located in a valley in the Eastern mountains at an altitude of 2,600 m.a.s.l.; however, it extends to the nearer hills, and settlements reach an altitude closer to 3,000 m.a.s.l. Since the number of settlements out of the 'urban perimeter' is considerable, and they belong to low income groups, which take the water from nearby creeks and consume it without treatment, the total figure for access to safe water for the city should be lower.

4.3.2.2 Effectiveness

The relation of what people are paid and the cost of living is the indicator selected to show how effective the economy and the infrastructure systems are in Colombia, that is, if the effectiveness orientor is satisfied in the support system..

4.3.2.2.1 Hours of paid work required to meet basic needs at actual minimum wage

According to El Tiempo (2000), in Colombia a nuclear family (two parents, two children) requires 5 times the minimum salary to live decently, that is, to satisfy their basic needs.

These basic needs or basic consumption items have been considered on a monthly basis for the case of living in a city:

- Food,
- Housing (rent as well as mortgage),
- House administration fees (which in Colombia is particularly high because it includes paying for security),
- Public services (water, electricity, telephone and gas),
- Transport,
- Children's education,
- Taxes,
- Health and pension contributions to the social security system; and
- Some leisure costs (once to the movies and to the hairdresser for all members of the family).

To earn 5 times the minimum salary means necessarily for a low-median class Colombian family that both parents should be working in paid employment. For the lower income population, even if both heads of the household are working, both wages together are very unlikely to be more than 5 times the minimum salary and this means that people are deprived of some of those basic needs.

4.3.2.3 Freedom of Action

As an indicator of freedom of action, urbanisation figures are selected as examples for the support system. The urbanisation process, as a result of economic development, has forced people to live in concentrated settlements where more employment opportunities and better salaries are available, but at the same time this process has restricted the mobility of people.

4.3.2.3.1 Percent of population living in cities

Colombia's figures of urbanisation indicate that 27% of the population lived in cities of more than 1 million in 1995 (World Bank, 2000). Other urbanisation numbers for Colombia have been shown in Table 4.15. Latin America as a region has the highest urbanisation figures in relation to the rest of the developing countries. The numbers are

closer to the developed world. However, the patterns of Latin America's urbanisation are different with respect to developed countries. In Latin American countries most of the urban dwellers live in the largest city, compared to some of the developed countries where the urban population is more evenly distributed among all cities (for example West European countries). The data about characteristics of urbanisation in the Latin America region are shown in Table 4.16.

In Colombia, there are four metropolitan areas (large urban agglomerations), the Capital City Santafé de Bogotá, Medellin, Cali and Barranquilla. Around 1950s, the population distribution among the Colombian cities had an important characteristic that no single city was significantly larger (less than twice) than the next in size (Parra, 1999). By the 1990s the pattern has undergone some changes; Bogotá's population consist of around 25% of all urban population and the gap between Bogotá's population and the second biggest city, Medellin, is becoming larger (Parra, 1999).

Table 4.16 Latin America & Caribbean Urbanisation Patterns
Source: United Nations, 1995

Agglomeration size	Number of agglomerations		Percentage of population living in urban areas relative to total population	
	1950	1995	1950	1995
Total urban areas			41.6	74
10 million or more	0	3	0	12
5 - 10 million	1	4	7.3	7.8
1 – 5 million	6	35	17.5	18
500,000 – 999,999	5	52	5.1	10.3
Fewer than 500,000	n.a.	n.a.	70.1	51.8

4.3.2.4 Security

To indicate if the support system (infrastructure and economy) is secure, indicators of energy, productivity and use, have been selected. Energy is a major resource; it plays a vital role for the economy of a country and subsequently for the whole system. In addition, for better illustration of the issue of energy in Colombia, other related information is presented.

4.3.2.4.1 Energy Productivity and consumption

Table 4.17 illustrates the figures of energy production and consumption for Colombia's economy. Indigenous production of energy in all forms has increased 163% from 1985 till 1995 (WRI, 2000). Mainly the production of solid and liquid fuel has contributed to this increase. Mineral carbon and petroleum have been very significant items of the country's exports. Hydrocarbons account for 21.3% of total exports and mineral carbon represents 76% of mineral resources exported (DNP, 2000). Despite this fact, Colombia imports electricity at an increasing rate, 6220 percent since 1985 (WRI, 2000).

Table 4.17 Energy production and consumption in Colombia
Source: WRI, 1986 for data of 1983; WRI, 1994; for data of 1991; WRI, 1998, for data of 1995

Energy indicators	1983	1991	1995
Total Commercial Energy Production (PJ)	770	1807	2242
Solid Fuel (PJ)	176	642	708
Liquid Fuel (PJ)	343	904	1247
Gas Fuel (PJ)	181	161	164
Primary Electricity (PJ)	71	100	123
Commercial Energy Consumption [8] (PJ)	733	806	941
PER CAPITA (GJ)	27	25	25*

* Calculated using Commercial energy consumption and population figure for 1995 from same source.

The increase in energy use experienced worldwide is linked, in Latin America, and in the developing world, to the need for providing minimum services to an expanding population and satisfying basic requirements of industry (WRI, 1996). Use of energy is necessary for the expansion of basic infrastructure, such as housing, transport systems, roads and vehicles and industrial facilities as population and demand grow.

Currently the total electricity consumption per capita (as only one part of commercial energy) in Colombia is lower than the average for Latin America. In 1997 Colombia consumed 885 KWh per capita where Latin America consumed 1402 KWh per capita (WRI, 1998). Although in Colombia, the electricity consumption tripled from 1970 till

[8] Commercial energy consumption is called "apparent consumption" because it is based on all domestic production plus net imports (imports minus exports) and minus net stock increases (World Bank, 1996).

1990, as shown in Figure 4.4, the per capita consumption of energy kept constant in the last few years and has started to decline since 1997. This relevant decrease in energy use is probably due to the economic recession of recent years, which carries a lack of infrastructure development (see Table 4.17 and Figure 4.4).

Moreover, the population growth rate has been declining since 1985 and at the same time the electricity imports have risen. From the same Figure 4.4 it is possible to conclude that residential consumption accounts for even less than half of the total consumption and that most of the energy supplied is absorbed by other sectors such as industrial and commercial. Therefore, the increases in energy production achieved in the last decades are predominantly export-oriented and the electricity generation sectors have not coped with internal demands, mainly from industry, forcing the country to import electricity.

The problems with electricity in Colombia became more evident in 1992. That was a year of the energy crisis. The effects of the El Nino climate phenomena on the country (long periods of drought) together with lack of planning and good management in the energy sector, mainly in the hydroelectric systems brought as a consequence a year of severe rationing in energy use. This fact can be appreciated in Figure 4.4 (but is most evident in Figure 4.5). Almost 70% of Colombia's electricity generation comes from the hydroelectric system (DNP, 2000).

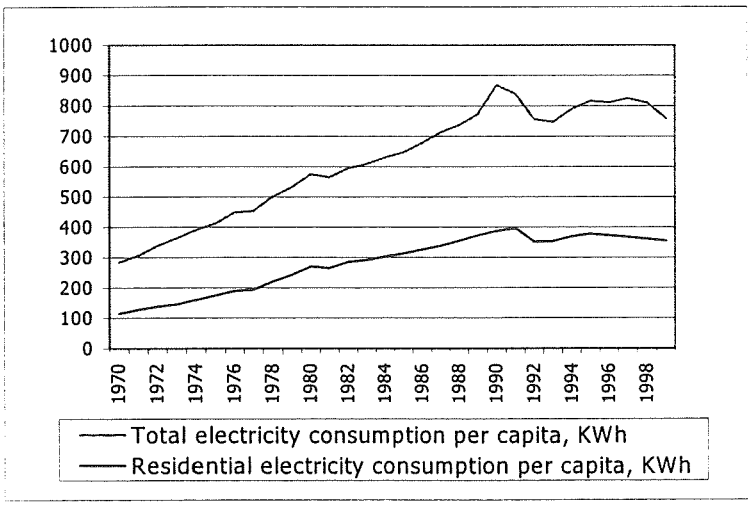


Figure 4.4 Electricity Consumption in Colombia, 1970-1999
Source: DNP, 2000

Another way of measuring energy productivity is through the relationship with Gross Domestic Product, GDP, of the country. In the last twenty years the use of energy in terms of the GDP has decreased, as shown in table 4.18. This decline means a lower energy use in relation to a unit of GDP, even though the GDP has increased 4.33% on average every year since 1970 (calculated from data from DNP, 2000). This measurement could represent a relative increase in energy efficiency in Colombia.

Table 4.18 Energy use in terms of GDP
Source: Calculated based on data from World Bank, 2000a

	1980	1997
Energy use per unit of GDP, Kg oil equivalent per PPP US$*	0.204	0.121

*GDP calculated using Purchasing Power Parity rates

Furthermore, if the rates of growth of GDP and electricity consumption are analysed over the last twenty years, it is possible to see that they are relatively linked as shown in Figure 4.5. In 1992 due to the energy crisis the figure for electricity consumption is negative and considerably lower and also it had an effect on the figure of GDP.

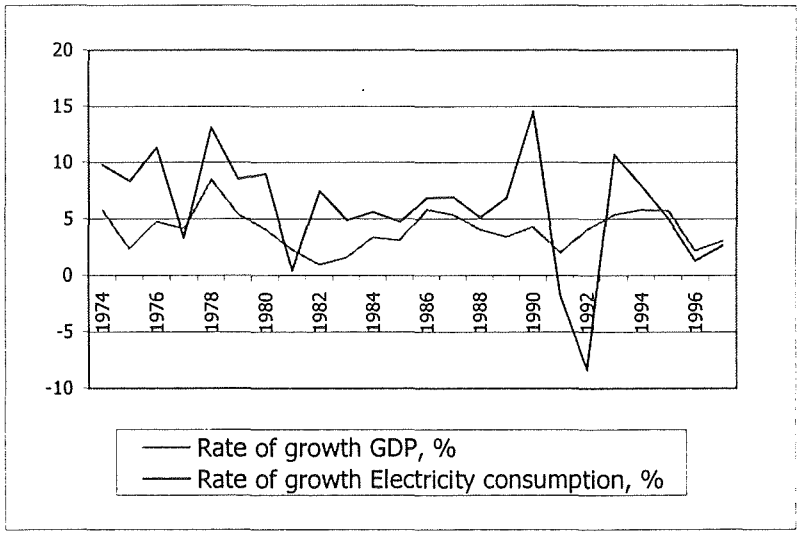


Figure 4.5 Rate of Growth of GDP and Electricity consumption
Source: DNP, 2000

4.3.2.5 Adaptability

Education is one of the basic elements that contribute to a better quality of life for a society. Education enables people to have better opportunities of self-realisation and better possibilities to adapt to environmental and social changes, making public investment in education essential at all levels. These are the reasons for selecting Investment rate in Education as indicator for the adaptability orientor of the support system.

4.3.2.5.1 Investment rate in Education

The investment in education from the central government in Colombia is shown in Figure 4.6 as expenditure in terms of GDP. The rate of expenditure has remained almost constant since the 1980s, at around 3% of GDP, with a slight reduction in recent years. Comparing this figure with other countries in the region, it appears that Colombia spends less in education than for example Mexico with 4.2% in 1993 and Cuba with 6.1%, but almost the same as Ecuador, 2.7%, and Chile, 2.6%, in 1993 (Infonacion, 2000). However, with regard to developed countries, Colombia's investment in education is much smaller. New Zealand for example spent 7% in 1992 and Australia 5.1% in 1991 (Infonacion, 2000).

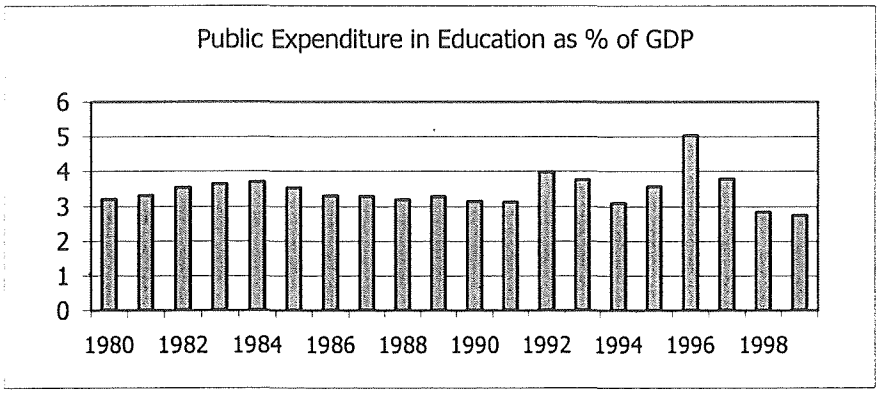
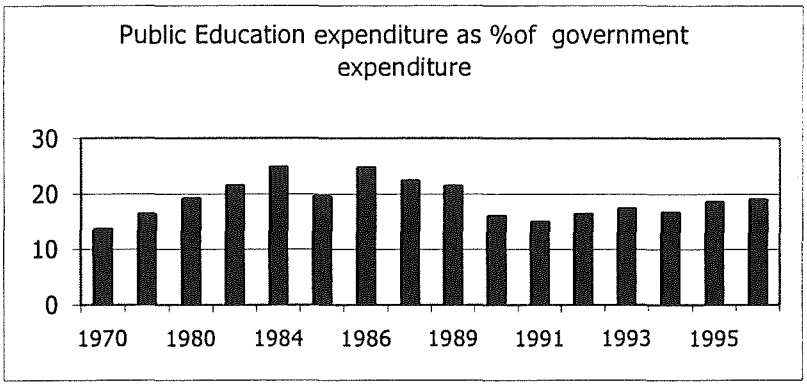


Figure 4.6 Public Expenditure in Education as % of GDP in Colombia
Source: DNP, 2000

Nevertheless, the investment on education in Colombia in the last 20 years seems to have an oscillating pattern, when looking closer at Figure 4.7, where the public expenditure in education is presented in relation to all government expenditure. In the late 1980s there was a peak when a higher proportion of the total government expenditure went to education. It dropped to almost the same levels registered in the 1970, and in the 1990s

started recovering again very slowly. However, data from Figure 4.6 of most recent years (from 1996 onwards) shows that the investment in education drops again, which coincides with lower growth rates of GDP, and as a result, the education sector (from public investment) is actually getting fewer resources.

Figure 4.7 Public Expenditure Education as % of Government Expenditure



Source: UNESCO, 2000

4.3.2.6 Coexistence

Ecological footprint has been chosen as an indicator of the level of coexistence between a society and its environment. The ecological footprint is the estimate of the amount of ecologically productive land required on a continuous basis to sustain current levels of resource consumption and waste assimilation for a given population (Wackernagel, 1996). In addition, a sustainable footprint can be defined as the ideal one, which falls into the available capacity of the world but have the lower impact on land resources. Hence the relationship between the actual ecological footprint versus a sustainable footprint is essential to look at for this sustainability analysis.

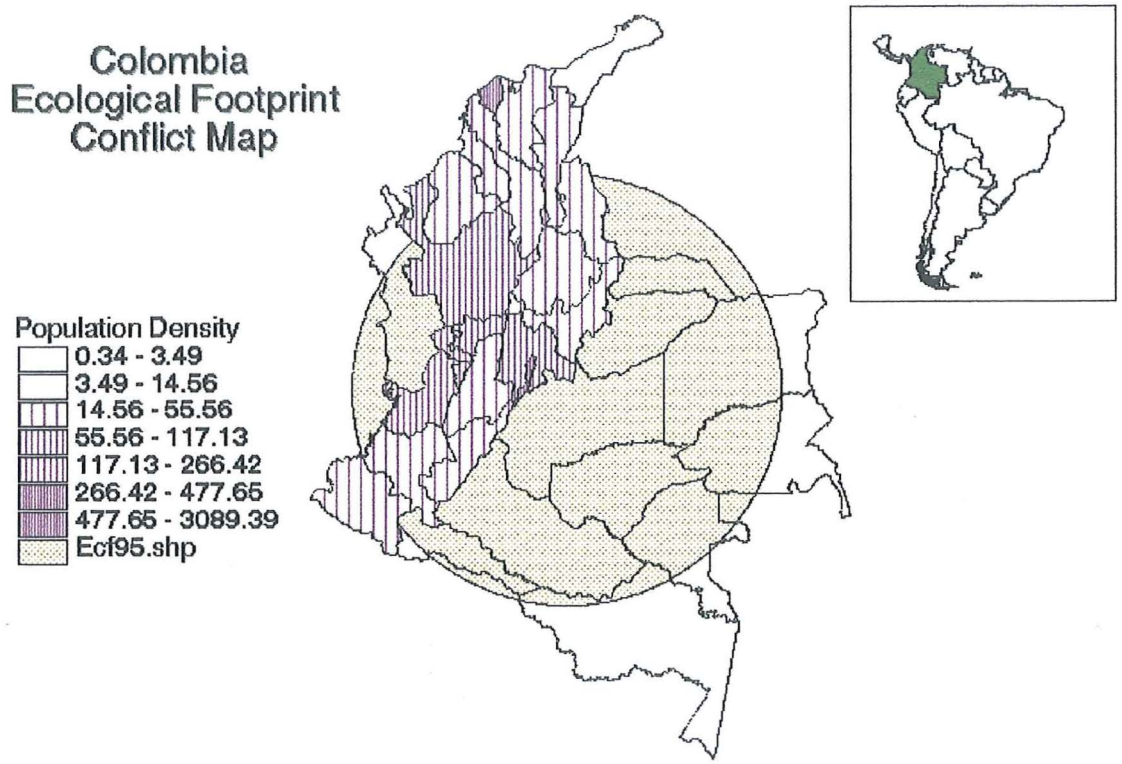
4.3.2.6.1 Ecological footprint vs. sustainable footprint

Using data from Redefining Progress (2000) Map 4.1 was elaborated using geographic information systems, GIS, through overlaying functions[9]. A circle with the equivalent size represents the Ecological Footprint for Colombia in 1995. The main assumption for this

[9] Geographic Information Systems allow the manipulation of geographic data. This map is based on vector structure data, which means that every polygon, in this case every province, has a punctual datum. In addition, two polygon coverages are overlaid: Population Density and Ecological Footprint.

visualisation of the ecological footprint is that all land resources used are provided from the country itself. Colombia's ecological footprint is 2.3 ha/cap whereas its available capacity is 4.9 ha/cap. In addition, the world's available capacity is just 1.9 ha/cap.
Although Colombia's ecological footprint is still lower than its available capacity and, as a consequence there is not a deficit (as shown by the size of the circle compared with the size of country), it is also possible to appreciate that there are conflicts with the population distribution and resources demand. The most populated provinces are located in the middle part of the country (the provinces with more than 55 people per square kilometre). They are few but they are using or demanding most of the land resources of the country.

Therefore, Colombia could be far from achieving a sustainable footprint because of inequalities in distribution of resources at the interior of the country, which are relevant issues when assessing sustainability of the whole.



Map 4.1 Ecological Footprint Conflict of Colombia[10]
Source: Ecological Footprint data from Redefining Progress, 2000
Population Density data from DNP, 2000
Note: Ecf95.shp represents the Ecological Footprint size of Colombia with data from 1995

4.3.2.7 Psychological Needs

For the psychological needs orientor migration patterns are selected as indicator for the support system in Colombia. Migration in Colombia can be seen as a response of the people who are suffering stress and frustration for the lack of opportunities due to problems with the infrastructure and economic systems in their places of origin. Although migration, and international migration, has increased worldwide, in developing countries it is motivated mainly by poverty and conflict (UNFPA, 1998).

[10] For other studies of the GIS incorporation in sustainable development indicators see Langaas (1997) and Winograd (1996). They conclude that the strong points for the implementation of GIS in indicators are the possibilities for data manipulation, data visualisation, use of databases and also the linkages of GIS and Internet data.

4.3.2.7.1 Migration patterns

Colombia has presented very dynamic patterns of migration, characterised by high interior mobility towards areas of relatively higher economic developments, mostly rural to urban migration but also a few rural to rural. In table 4.19 is presented the highest emigration numbers by province in Colombia. Indeed, some of the provinces with higher emigration rate have been suffering from the armed conflict mentioned in a previous chapter. Noticeably, provinces located far away from main economic centres (i.e. Amazonía and Orinoquía Region) have as large emigration numbers as some located closer (i.e. Andean Region). The lower emigration numbers correspond to the more urbanised provinces including the capital city.

As an example of another country of the region, in Mexico 5 percent of population emigrated between 1990 and 1995 from their place of origin to another locality at the interior of the country (INEGI,2000)

Table 4.19. Highest Emigration Rates in Colombia
Source: DNP, 2000

Province (Region)	Emigration rate per 1000 people From 1988 - 93
Guaviare (Amazonía)	48.73
Caqueta (Amazonía)	29.79
Meta (Orinoquía)	29.47
Quindio (Andina)	26.85
Tolima (Andina)	25.95
San Andres (Atlántica; Island)	25.53
Vichada (Amazonía)	25.40
Casanare (Orinoquía)	24.95
Boyaca (Andina)	24.05
Guainia (Amazonía)	23.99
Arauca (Orinoquía)	23.41
Cesar (Atlántica)	23.24
Cundinamarca (Andina)	22.95
La Guajira (Atlántica)	22.88

4.3.3 Natural Subsystem

4.3.3.1 Existence

The study of the patterns and changes of land use could provide an indicator of the basis for the existence of the natural system of the country. Whether Colombia as a system is compatible and able to exist in its environment is considered here through looking at the Loss of agriculture land and forest.

4.3.3.1.1 Loss of agriculture land and forests

Before going to analyse the losses of agriculture land and forest as indicator, is relevant to mention the current land use patterns for the whole country. Land use categories looked at are cropland, permanent pastures, forests and woodland and other land uses. This classification is based on the data reported by WRI (2000). Cropland includes land under temporary and permanent crops, as well as temporary meadows and fallow. Forest and woodland encompasses land under natural or planted stands of trees. Under other land uses are included uses as uncultivated land, grassland not used for pasture, built on areas, wetlands, wastelands and barren land, and roads (WRI, 2000). Figure 4.8 shows recent data for land use in Colombia.

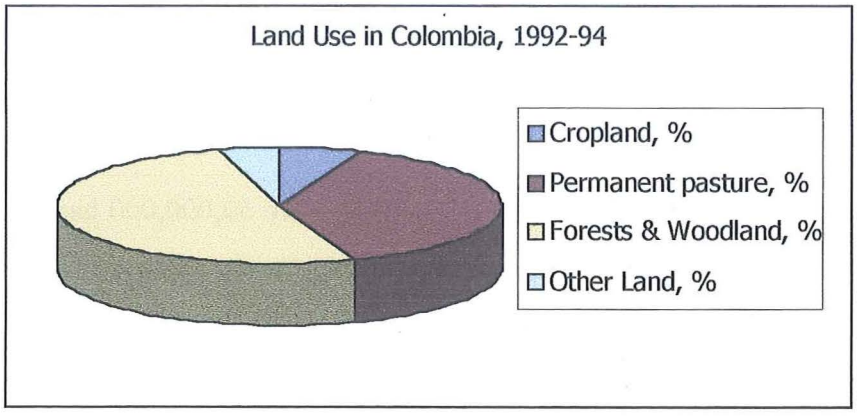


Figure 4.8 Land Use in Colombia, 1992-94
Source: Percentages are calculated based on data from WRI, 2000

Figure 4.8 indicates that forests and woodland, with 51%, and permanent pastures, with 39%, occupy the largest extensions of Colombian territory. The remaining 10% is

distributed evenly between cropland and other uses. However in terms of agricultural output Colombia is divided between crops (two thirds) and livestock (one third). The agricultural sector, including forestry and fisheries, accounts for approximately 14 percent of GDP and employs 28.5 per cent of the labour force (FAO, 2000).

In the last 40 years the use of land in Colombia has, apparently, undergone only slight changes; this is shown in Figure 4.9. In the percentage distribution, permanent pasture and other land uses have increased a little while cropland has remained almost constant with regard to the total land area. On the other hand forestland has been reduced; although in percentage terms with regard to the total land the change is still very small, nevertheless in terms of real numbers the changes are more significant.

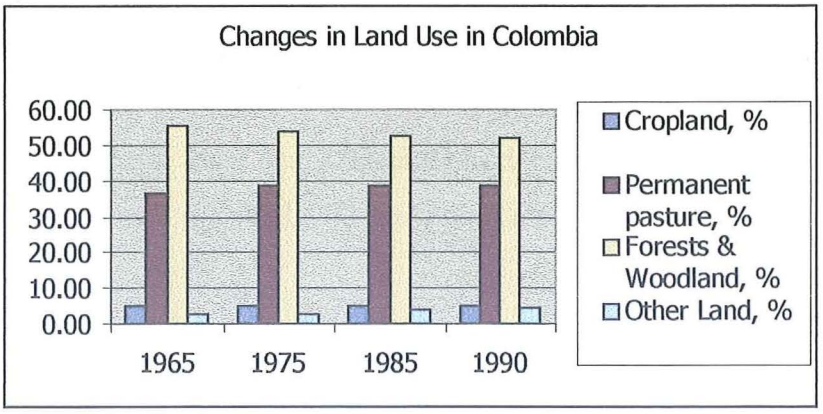


Figure 4.9 Changes in Land Use in Colombia, 1965-90
Source: FAO, 2000

According to the data from FAO (2000) in 1961 there were 59,000,000 hectares of forest and woodland, and comparing this with the number given in the same source for 1990, of 54,299,000 there is a loss of approximately 162,000 hectares per annum. However, most recent estimations of the Ministry of Environment in Colombia (2000) indicate that every year between 600,000 and 900,000 hectares are deforested.

Another interesting indicator related to appropriate land use used by WRI is 'Domesticated Land'; this represents roughly the degree to which national landscapes have been heavily modified through agricultural use. Domesticated land is defined as the sum of cropland and

permanent pasture land uses (WRI, 2000). Table 4.20 presents the figure for domesticated land for some Latin American countries, including Colombia, together with the data of total land area and population density.

Table 4.20 Domesticated Land for some Latin American Countries
Source: WRI, 2000

Total Indicators	Colombia	Argentina	Mexico	Peru
Total land area, 000 ha	103,870	273,662	190,869	128,000
Population density, per 100 ha, 1996	351	129	486	187
Domesticated land, as a % of land area, 1994	45	62	55	24

Colombia is the fifth largest country in Latin America (that is both South and Central America), however the third most populated, after Brazil and Mexico. On average the domesticated land in South America is 35%, while in Central America it is 53%. The Colombian figure is just in the middle of this range; nevertheless it is indicating a considerable degree of transformation of the original or remaining natural landscape through agricultural use, mainly the increase in pasture land. Taking into consideration that most of the deforested land is subsequently used for pasture an increase in domesticated land could be an indirect indicator of the loss of forestland.

4.3.3.2 Effectiveness

The effectiveness category concerns the effective use of resources. The ratio between emissions and economic output gives a measurement of how efficient and effective the system is in the production of Carbon Dioxide (CO_2), one of the main greenhouse gases. Therefore, Greenhouse gases emissions per economic output is selected as indicator for the effectiveness orientor in the natural system. When referring to carbon emissions from fossil fuel combustion within an economy this indicator is also called 'carbon intensity' (Worldwatch Institute, 2000).

4.3.3.2.1 Greenhouse gases emissions per economic output

Colombia's most recent figures for CO_2 emissions from industrial processes and their relation to the economic output[11] are shown in Table 4.21. Industrial processes, that generate CO_2 from the burning fossil fuels and the production of cement, constitute the predominant anthropogenic source of greenhouse gases. For comparison, data from other South American countries are also included in Table 4.21, more precisely the bigger economies of the subcontinent.

Table 4.21 CO_2 emissions from industrial processes per economic output for some South American countries in 1995
Source: Calculated based on data from WRI, 2000

1995	CO_2 Total emissions, 000 metric tons	CO_2 Emissions per capita, metric tons	GDP, million US	Emissions per economic output, CO_2 metric tons/ 10^3 US GDP
Venezuela	180243	8.2	75016	2.403
Bolivia	10475	1.4	6131	1.709
Colombia	67524	1.9	76112	0.887
Chile	44104	3.1	67297	0.655
Peru	30561	1.3	57424	0.532
Argentina	129464	3.7	281060	0.461
Brazil	249196	1.6	688085	0.362

The largest emissions of the subcontinent come from Brazil, however it is the most efficient in relation to its economic output. Brazil is among the most 'industrialised' countries of the region. Venezuela has the highest emissions per capita and has as well the highest emissions per economic output ratio; this means higher unit of CO_2 emissions per unit of economic output. Colombia is in the top three most inefficient countries of this selected group. Although this ratio has overall declined with various fluctuations in the last twenty years, see Figure 4.10, at the same time the industrial emissions have constantly increased as illustrated in Figure 4.11.

[11] The indicator selected for economic output was GDP, since it measures the final output of good and services produced by the domestic economy.

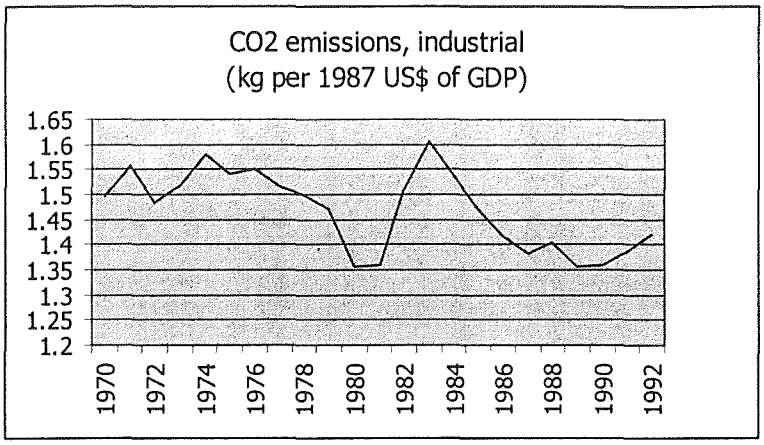


Figure 4.10 Colombia's CO_2 industrial emissions per economic output
Source: World Bank, 1995

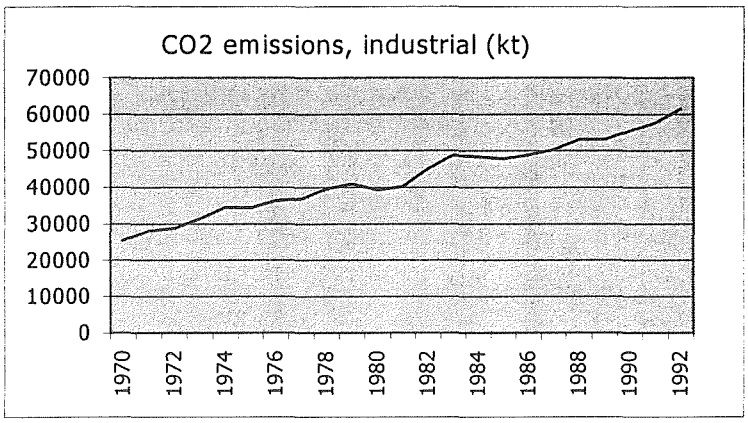


Figure 4.11 Colombia's CO_2 emissions from industrial sources
Source: World Bank, 1995

On the other hand, CO_2 anthropogenic emissions also originate from land use change, principally deforestation. In Colombia, in 1991 there was 110,000,000 metric tonnes of CO_2 released by land use change and this datum is more significant, being almost double the emissions from industrial processes of 61,493,00 metric tonnes for the same year (WRI, 1994).

4.3.3.3 Freedom of action

The satisfaction of the freedom of action orientor allows the system to cope with challenges posed by environmental variability. The native forest, of unmeasurable value

itself, plays a very important role in the current balance of CO_2 emissions therefore it has been selected as an indicator of freedom of action of Colombia's natural system.

4.3.3.3.1 Fraction in Native forest

Data from the World Resources Institute in 1992-94 showed that half of the land in the country was under forests and woodland, see Figure 4.8. One of Colombia's greatest resources is the tropical rain forest of the Amazon Region and the El Chocó on the Pacific Coast. The tropical rain forests are a crucial resource for the World in terms of biodiversity, absorption of carbon dioxide and as a source of wood and forest goods, such as food and medicinal plants. At the same time, it is the home for numerous indigenous groups. Latin America and the Caribbean comprise half of the world's humid tropical forests (MacKerron, 1995); by 1995 in Colombia there were 52,862,000 hectares of natural forests (WRI, 2000).

For the Ministry of Environment in Colombia (2000) the native primary forest, the one that has not been affected for agriculture and wood crops and human transformation, is estimated to occupy 44.8% of the total area of the country. Secondary forests, which have been modified by human intervention through selective processes of felling and fire for agriculture and forestry products, account for 4% of the territory. Lastly the forest plantations of wood species for economic purposes represent approximately 0.1%. Table 4.22 shows the distribution of forest in Colombia by regions.

Table 4.22 Forest in Colombia by Regions (ha)
Source: Ministry of Environment, 2000

Regions	Total Area	Potential Area of Native Forest	Actual Native Forest Cover Area	Deficit For Deforestation	Forest Plantations[12]
Colombia	114'374.185	83'408.117	53'100.000	30'123.000	304.206
Atlántica	11'526.305	5'320.597	500	4'821.000	19.751
Andina	29'661.930	20'199.775	7'700.000	12'400.000	182.151
Pacífica	10'259.575	9'592.702	5'500.000	4'000.000	94.717
Amazonía	40'500.000	35'281.052	32'300.000	2'981.000	1.803
Orinoquía	22'284.232	13'013.991	7'100.000	5'921.000	5.784

[12] There is a small disagreement regarding the forest plantation percentage. If calculating it from the data from the table the percentage with regard to total forest area is abut 0.2%, while in the same source (Ministry of Environment, 2000) in the text is written 0.1%.

The consequences of the increase in deforestation rate and, as a result, in the loss of forestland and forest ecosystems are considerably negative. From one viewpoint, deforestation threatens extinction of all forms of life supported by the forest; tropical forests possess at least half or perhaps more of the world's plant and animal species (MacKerron, 1995). From another viewpoint, deforestation diminishes and depletes a valuable resource. The Ministry of Environment in Colombia points out in its home web page that with the present deforestation rate the native forest will disappear in 40 years (2000). Furthermore losses in forestland have enormous consequences for the life of indigenous groups, whose livelihoods are in mutual relationship with the forest.

4.3.3.4 Security

Whether the system is able to protect itself from the detrimental effects of environmental change is studied under the security category. For environmental changes the climate phenomenon of El Niño will be considered here. Climate changes, whether natural or human induced or a combination of both, have imposed changes on the ecosystems and society.

4.3.3.4.1 Consequences of the climate variability: El Niño phenomenon

El Niño is the strongest natural interannual climate fluctuation, with a frequency between two and seven years (Timmermann, 1999). It refers to a warming of the Tropical Pacific basin that occurs in association with a weakening of the trade winds. The flip side of El Niño is la Niña and it is characterised by stronger cold sea surface temperatures and stronger trade winds (McPhaden, 1999). Both related phenomena are known as the El Niño Southern Oscillation (Timmermann, 1999). Although El Niño originates in the equatorial waters of the Pacific Ocean it influences the entire global climate system.

El Niño phenomenon has been known to fishermen in the South American Pacific Ocean since ancient times. It used to occur around Christmas time and therefore its name, The Child, in Spanish (World Meteorological Organisation, 1986). However, the marked effects of this phenomenon started to be known more recently. The strongest effects of the El Niño phenomenon have been felt in 1982-83 and 1997-98.

In Peru the physical damage caused by the 1982-83's El Niño was estimated as $US 1,996 millions (World Meteorological Organisation, 1986). Furthermore, a loss of 23,000 lives and $US 33 billion in damage was caused by El Niño of 1997-98 years (McPhaden, 1999). These figures comprise mostly losses in farming, fisheries and infrastructure, without taking into account the inestimable ecological and archaeological losses.

Some of the direct effects of El Niño on the Colombian environment that the Colombian Institute of Hydrology, Meteorology and Environmental Studies, IDEAM (2000), has identified are:

- The surface temperature of a large extension of the Pacific Ocean has presented increases of 2 – 3°C above normal patterns, of 25 and 26 °C, at the times of El Niño phenomenon. As a consequence diverse marine ecosystems have been altered, mainly corals, and various marine life species, such as whales and turtles, have changed their migration paths.
- In the Pacific Coast cities of Tumaco and Buenaventura the sea level has increased between 20 to 40 centimetres during El Niño years.
- With respect to climate effects, The El Niño phenomenon is affecting the air temperature and precipitation patterns.
- In the Pacific Region, in the valleys of the Andes Region and in the Atlantic Coast of the country there has been an evident increase of the air temperature during the day. In addition, there is a decrease in the air temperature in the early morning, which has caused unexpected frosts in the highlands and tablelands.
- The rainfall regimen has had different alterations in the different years of El Niño. However, generally there is a deficit of rainfall in the Andes and Atlantic Regions and northern part of the Pacific Region. In contrast, at the same time there is a heavy rainfall in the southern part of the Pacific Region, the eastern shed of the Cordillera Oriental and some places of the Amazon Region.
- Other consequences of the drought periods resulting from El Niño are the increase of the UV radiation that affects the northern part of the country and the higher risk of forest fires.
- As a result of the changes in the rainfall and in the related hydrological cycle, there have been changes in the water dynamic, availability and distribution. In some regions

the deficit of water has reached more than 30 %, which has considerable consequences for potable water supply systems, irrigation systems and electricity generation.

4.3.3.5 Adaptability

To satisfy the adaptability orientor the natural system should be able to learn, adapt and self organise to generate more appropriate responses to challenges posed by environmental change. Water is an infinitely precious resource; it plays vital roles for human and natural systems. Anthropogenic pollution, such as the discharge of wastewater from municipal, agricultural and industrial sources without treatment, reduces the water's quality and affects its ability to recover itself from the environmental variability. At the same time dependant water life, human and support sub-systems are affected. In fact, worldwide around 10 million people or more die annually due to dirty water, causing at the same time untold economic damage (Hinrichsen, 1996). Therefore, Unpolluted Waterways has been selected as indicator of adaptability of the natural system.

4.3.3.5.1 Unpolluted waterways

In developing countries the lack of wastewater treatment is very significant. Most of the water discharges from both urban and rural uses go directly into the waterways, rivers, lakes and oceans, without previous treatment. This has a considerable effect on other subsequent uses of the waterways downstream. In China, for example, approximately 700 million people--over half the population--consume drinking water contaminated with levels of animal and human excreta that exceed maximum permissible levels by as much as 86% in rural areas and 28% in urban areas (Wu, 1999). In addition, in Mexico City the water supply source is rapidly being depleted and is becoming increasingly vulnerable to contamination to the extent that the Basin of Mexico is incurring groundwater pollution, land subsidence, and changes in groundwater flow (Shannon, 1996).

By 1995 in Colombia only 4% of all municipalities had some wastewater treatment system (Plan Nacional de Agua, 1995 referenced in Parra, 1997). Colombian rivers receive the majority of water discharges from all socio-economic activity of the country as well as the sediments originated from erosion processes. Concentrations of solid particulate as high as 2000 mg/litre have been found in the rivers of the Andes region (IDEAM, 2000), where most of the population live. As a result of this type of pollution being a combination of

municipal, industrial and agricultural waste, the absorption of sunlight and oxygen in the water are limited, resulting in its reduced capacity for natural biodegradation and purification. As a consequence Colombian rivers in the Andes and Atlantic regions are considered of high risk for human use and demand high costs for treatment due to cumulate levels of pollutants.

4.3.3.6 Coexistence

Coexistence and interaction with other sub-system are essential for a viable overall system. As an indicator of the degree of coexistence of the natural subsystem the endangered species have been selected. The human population cohabits the planet with a large number of other species, however at present the relationship of human with non-human species has not been respectful enough resulting in the threatened and actual extinction of many animal and plant species.

4.3.3.6.1 Endangered species

Worldwide the global extinction crisis has shown dramatic declines in populations of many species. A total of 11,046 species of plants and animals are threatened, facing a high risk of extinction in the near future, in almost all cases as a result of human activities (Conservation International, 2000). Since 1996 the actual number of critically endangered species has increased, despite all convention and biodiversity conservation agreements.

Colombia is one of the countries of the world with high biodiversity due to its position, close to the Equator and its physical geography; the Andes mountains, the Amazon and Chocó jungles and two large coasts on the Pacific and the Atlantic Ocean. Colombia holds between 10% and 14% of all biological diversity of the planet and its surface area accounts for just 0.8% (Ministry of Environment, 2000). Table 4.23 shows the countries with the highest biodiversity in the world by number of species, indicating Colombia's privileged position.

Table 4.23 Countries with higher biodiversity by number of species
Source: Colombian Ministry of Environment, 2000

Country	Vascular Plants	Mammals	Birds	Reptiles	Amphibious
Colombia	(2)	456 (4)	1815 (1)	520 (3)	583 (1)
Brazil	(1)	524 (1)	1622 (3)	468 (5)	517 (2)
Indonesia	(3)	515 (2)	1531 (5)	511 (4)	270 (6)
Mexico	(5)	450 (5)	1050 (10)	717 (2)	284 (4)
Venezuela	(7)	288 (10)	1360 (6)	293 (13)	204 (9)
Ecuador	(8)	271 (13)	1559 (4)	374 (8)	402 (3)
Peru	(9)	344 (9)	1703 (2)	298 (12)	241 (7)
Australia	(13)	282 (12)	751 (14)	755 (1)	196 (11)
Madagascar	(15)	105 (17)	253 (17)	300 (11)	178 (13)
China	(4)	499 (3)	1244 (8)	387 (7)	274 (5)
Philippines	(17)	201 (16)	556 (16)	193 (17)	63 (17)
India	(12)	350 (8)	1258 (7)	408 (6)	206 (8)
Papua New Guinea	(11)	242 (15)	762 (13)	305 (10)	200 (10)
USA	(10)	428 (6)	768 (12)	261 (16)	194 (12)
Malaysia	(14)	286 (11)	738 (15)	268 (14)	158 (14)
South Africa	(6)	247 (14)	774 (11)	313 (9)	95 (15)
Democratic Republic of Congo	(16)	415 (7)	1094 (9)	268 (14)	80 (16)

Note: The number in the parenthesis is the position with respect to the world in number of species and the actual number corresponds to the total number of each particular specie.

Nevertheless, a considerable number of species in the country, indigenous and non-indigenous, are facing threats to their existence. The impact of human activities has severely affected the habitat of these species. In Colombia, primarily activities such as deforestation and expansion of agriculture have largely modified forests and rivers, which are natural habitats for animals and plants. But also other human activities, such as the illegal trade of fauna and flora and also hunting, are contributing to the risk of extinction for some species. Table 4.24 shows Colombian figures of threatened species by 1996.

Table 4.24 Colombia's endangered species.
Source: WRI, 2000

Species	Threatened species
Birds	64
Mammals	35
Reptiles	15
Amphibians	0
Freshwater fish	5
Higher flowering plants	376

Note: Data of 1996, except for higher plants data of 1993.

4.3.3.7 Psychological Needs

Psychological needs are a system-determined basic orientor, in contrast with previous orientors, such as adaptability, security, freedom of action, etc., which were environment-determined. Only sentient beings can experience psychological needs. Depending on their culture, communities of human beings have developed a sense of awareness and concern regarding the state and changes in their environment. The degree of psychological stress about the environment has increased as many people are suffering direct consequences of environmental degradation, for example communities that live closer to industrial complexes and cities are exposed to air pollution levels that have health consequences.

4.3.3.7.1 Level of concern about resources and environment

To demonstrate the level of concern or awareness of Colombian people with regards to Colombia's environmental changes, the number of grass roots non-governmental organisations is explored here. As an illustration the changes in environmental legislation are also commented upon.

At an institutional level, before 1993 Colombia had a very disperse environmental legislation. However it was not until 1993 that a proper Environmental Law was sanctioned and The Environmental National System (SINA) was created. The SINA in Colombia comprises norms, orientations, resources, programs and institutions to carry out the environmental polices and laws according to the 1991 National Political Constitution. The head institution at national level is the Ministry of Environment, at regional level there are 'Corporaciones Autonomas' which are the environmental authorities. National research institutes are part of SINA, such as the Institute of Hydrology, Meteorology and Environmental Studies, already mentioned in this chapter. SINA is also integrated by the non-governmental organisations, NGOs.

With regard to NGOs, just for the province of Cundinamarca, where the capital city and the major industrial area of the country are located, more than 70 non-governmental organisations are registered as environmentalists within the Ministry of Environment 2000). In the province of Chocó, in the richly bio-diverse rain forest of the Pacific Region, there are 25 NGOs registered. However for provinces of the Orinoco region and some of the Amazon region there are no registries in the same database of the Environment

Ministry. Centralisation is still a big problem for those remote and isolated regions of the country. Greater support from the government would ensure more consolidated organisation of the communities, whose awareness for conservation is believed to be higher since the majority is from the indigenous population.

4.4 Summary

This chapter has described an extensive list of sustainability indicators by orientor categories and by three major subsystems: human, support and natural. Diverse sources were consulted aiming to provide a true picture of Colombia's situation.

A summary of the indicators of sustainability for Colombia is shown in Figure 4.12. This is a matrix that illustrates the state of every indicator with a correspondent traffic light (Peet and Peet, 2000). According to the trend or situation described in the chapter for every indicator a red, yellow or green light has been assigned to it. Thus a red light indicator means that the orientor or basic need it represents is not adequately satisfied. This, in turn, means a threaten for the sustainability of the whole system. Therefore, The red and yellow lights in the matrix will be subject to a further analysis in the following chapter.

Orientors	Human Subsystem	Support Subsystem	Natural Subsystem
Existence	Population growth rate	Percent of people without access to basic public services	Loss of agriculture land and forests
	Poverty		
	Life Expectancy		
Effectiveness	Unsatisfied basic- needs	Hours of paid work required to meet basic needs at actual minimum wage	Greenhouse gas emissions per economic output
	Social security		
Freedom of Action	Unemployment rate	Percent of population living in cities	Fraction in native forest
	Informal sector		
	Housing affordability		
Security	Victims of the armed- conflict	Energy productivity	Consequences of the climate variability: El Niño phenomenon
	Crime Rate		
Adaptability	Adult literacy rate	Investment rate in Education	Unpolluted waterways
	Access to education		
	Dependency ratio		
Coexistence	Quality of life of indigenous-communities	Ecological footprint vs. sustainable footprint	Endangered species
	Income distribution		
Psychological needs	Alcohol, tobacco and drug-consumption	Migration patterns	Level of concern about resources and environment
	Lifetime fraction available for-leisure		

Figure 4.12 Traffic light matrix as summary of the Sustainability indicators for Colombia

Chapter 5. Mapping the Sustainability Analysis though Conceptual Models

The objective of this chapter is to analyse and draw conclusions concerning the data that was collected and described on indicators of sustainability for Colombia From the application of Bossel's framework for the system of Colombia 31 sustainability indicators were described, within the data available, for the three subsystems, human, support and natural. A follow-up of the systems methodology will be done. That is, to consider the relationship between the subsystems and their elements and to find whether or not the basic needs or 'orientors' of the whole system are satisfied in such a way as to ensure Colombia's viability and sustainability.

For that purpose this chapter will be divided into two sections:

- ☑ General Review: this is the overall conclusion on the facts and trends described in the indicators and how they relate to the orientors or basic needs of the whole system,
- ☑ Specific Review: that is to look at every subsystem, its elements and their relationships. Conceptual models will be drawn to visualise causal relationships based on the information gathered.

These two elements of analysis will enable us to answer the research questions of this thesis: whether Colombia can offer to its people a sustainable living and what the key links are between water resources and sustainability in the context of Colombia.

5.1 General Review

Taking into consideration the definition of sustainability adopted in this study[13], the first conclusion upon reading the indicators for all human, support and natural systems and the

[13] The definition of Sustainability adopted and used for this thesis, which is discussed in a previous chapter, is as an ethical principle, and refers to "for sustainable living all people have their basic needs satisfied, so they can live in dignity, in healthy communities, while ensuring the minimum adverse impact on the natural system, now and in the future" (Peet and Peet, 2000:3)

summary matrix (Figure 4.12) is that Colombia, as a whole system, is not offering a sustainable living to its people. This assertion given the worldwide trends is predictable. However, in the case of Colombia, it has a critical dimension.

The average standard of living of the Colombian population is decreasing. The increase of poverty and the percentage of people with unsatisfied-basic-needs indicate a critical deterioration in the quality of life for Colombians and a real threat to their existence. The unemployment rate and unemployed numbers growing at the same time as increases in the cost of living, clearly indicate the lack of freedom of action for the people to secure themselves better opportunities.

The intensification of the internal armed conflict and its consequences shows how the Colombian population's need for security is not satisfied. Moreover, the disintegration of Colombia's society is another high cost of this continuous political struggle, which threatens lives and violates fundamental human rights. This in turn shows, in a broader sense, the lack of effectiveness of Colombian social organisations, institutions and Government to deal with and to interact with other systems' elements (coexistence orientor).

Another important factor in the satisfaction of the psychological needs orientor is the right to have and enjoy a pure and healthy environment. Nevertheless, Colombia's great biodiversity, native tropical rain forests and endowment of natural resources, such as water, are threatened with extinction. This destruction of natural and cultural heritage undermines the essential elements for what is referred to here as sustainable living of the Colombian community. Furthermore, urbanisation and violence have pushed the majority of Colombians from the countryside to crowded urban settlements where a clean environment is very rare, and water and air pollution are striking problems.

On the other hand, only a few indicators show positive trends, such as literacy, life expectancy and population growth rate, indicating that needs within human and support sub-systems are being satisfied mostly for the adaptability orientor. However, access to education, one of the key elements here, is becoming increasingly affected by the contemporary restructuring measures of Colombia's economy, such as privatisation. This

in the long term affects the ability of people to generate appropriate responses to the environmental - societal changes simultaneously affecting their living standards.

These preliminary general conclusions of the sustainability indicators, apart from demonstrating how vital it is to analyse the sustainability of a developing country, with all the particular situations of Colombia, lead us to explore the specifics of the problems.

5.2 Specific Review through Conceptual Models

5.2.1 Preamble

To look in detail at each subsystem it is necessary to disaggregate them into their elements and interrelationships. As explained earlier, in the methodology chapter, every subsystem—human, support and natural—consists of 'potentials', which are the most essential elements that should be maintained for the sustainability of the whole system.

The identification and analysis of the potentials of the system, their changes and behaviour, will allow us to find the unsustainabilities or most unsatisfied needs of the country. In order to achieve this, the proposed step is to go through the subsystems to determine the essential potentials and then to elaborate 'conceptual models' for them.

5.2.1.1 What are conceptual models?

A model is a representation. Hartmut Bossel, in his research about modelling, asserts that simplified and aggregated models need to be used in order to describe a real system; and these models "–hopefully- contain the essential features of the real system" (1998:37). Similiarly, Ford in *Modelling the Environment* states that a model "is a substitute for a real system" and those models are useful because they can be manipulated and in that way "they help to learn something about the real system they represent" (1999:3).

Thus in the context of studying sustainability, models are human made pictures of the world that surrounds us; they enable us both to understand the complexity of the systems that support life, in all forms, and their interaction with the systems created by humans, for example the economy and infrastructure system.

Senge in *The Fifth Discipline* (1990) calls these models **mental models** because they show the way people see their world and how it works. Similarly, Sterman (2000) uses mental models as the interface between the real world and the virtual world. The virtual world comprises formal models and simulations, which allow experimentation and play a successful part in learning about complex systems.

Since the world to be modelled is not simple, models can be developed further and be complemented with mathematical formulations and simulations for dynamic and complex situations. Nevertheless, for this thesis the models utilised are just the mental models and considerations of the author and they are simplifications of the reality in Colombia.

For this study simplified pictures or representations of Colombia's essential sustainability elements (**potentials**) will be suggested and they will be called **conceptual models**. The process of developing conceptual models attempts to gain an understanding of the main factors that influence the sustainable living of Colombian people, the way they are affecting the identified potentials and how they are interrelated.

The starting point is Hartmut Bossel's conceptual model based in systems theory. For Bossel the world is represented through the interaction of systems, a 'world of systems' (1998:35) as described in Chapter 3. Thus, the conceptual models suggested for Colombia will be linked with Bossel's model for the world. The sustainability indicators for Colombia, derived from Bossel's methodology, support the conceptual models as well.

5.2.1.2 Model elements

The systems of interest here are 'state determined systems' (Bossel, 1998). In order to describe and model these systems it is necessary to identify the most relevant variables. Their state is central for the development of the system so they are called 'state variables'. Moreover, for the complete description of the system it is necessary to use other variables that are called 'parameters'. Their values affect the state variable but they are independent of the system (Bossel, 1998).

For the conceptual models suggested here the potentials will be the state variables. Given that for the sustainability and viability of a system the potentials are vital, they will become

the state variables of the analysis of Colombia as a system. In addition, the elements or variables that determine the changes on the potentials will be the parameters.

5.2.1.3 Influence Diagrams and Feedback Loops

Once the state variable and the parameters have been identified, the relationship between variables should be established. In order to do so 'influence diagrams' will be used. Influence diagrams are a technique to illustrate the cause and effect relationships or connections between variables.

Each influence or causal relationship has an associated direction and polarity. Thus one variable, the cause, can affect another one, the effect, in a positive or a negative way, depending on whether the increase in the cause leads to an increase or decrease in the effect.

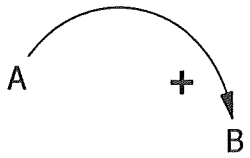


Figure 5.1 Simple Influence Diagram. Positive connection between A and B, meaning both variables change in the same direction and A causes B.

Besides, the influence diagrams allow the representation of loops, also called causal loops or feedback loops. To identify the type of feedback or overall polarity of the loop it is necessary to count the number of opposing links. An even number of opposite links implies positive feedback and an odd number implies negative feedback (Vensim User's Guide, 1988-1994). A positive feedback is known as reinforcing whereas a negative feedback is a balancing feedback.

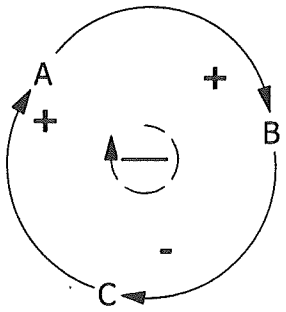


Figure 5.2 Negative Feedback Loop

What follows is an attempt to elaborate the conceptual models for the potentials of Colombia, which are recognised as fundamental for the sustainability of the total system. Influence diagrams will be utilised and they will be based on Bossel's model.

5.2.2 Quality of Life as a Potential of the Human Subsystem

The selection of this potential is based on the elements suggested by Bossel in his model of the anthroposphere and its systems (Bossel's original model is shown as Figure 3.2 in the chapter three). Within the human system there are three major systems. The make up of these subsystems is based on a number of elements that were described in detail in the Methodology chapter.

For the study of the human subsystem in Colombia it is proposed to focus on the concept of **Quality of Life** as a **potential**. This is because Quality of Life can be seen as an aggregate or as a synergic notion, where only the satisfaction of all the fundamental needs of people, in all dimensions, enables them a Quality of Life. In other words, Quality of Life represents the potential that should be maintained in order to achieve sustainability and viability for the human system.

Furthermore, this concept matches other sectors suggested by Bossel. For example, he suggests (1999) that individual development comprises civil liberties and human rights, equity, health, qualifications, life planning horizon, among others. Ultimately, all of these sectors represent potentials within the individual development system and Quality of Life combines some of these.

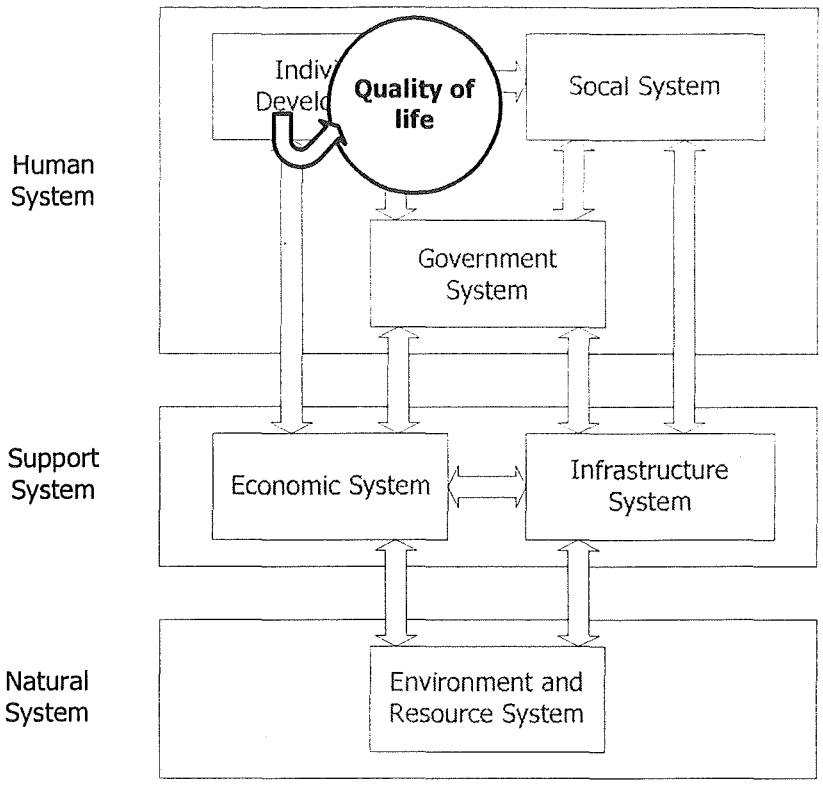


Figure 5.3 The Potential of Quality of Life within Bossel's model for the anthroposphere

Note: In the upper part of this diagram Socal should read Social

5.2.3 Conceptual model for the Quality of Life

In order to gain a deeper insight into the dynamics of the Quality of Life a conceptual model will be developed. Quality of Life will be the state variable of the model because it represents the main stock variable that grows or depreciates as a result of the interaction of other variables, such as health, employment, community ties or human rights in the country.

The next step for building up the model is to identify the parameters or those variables that affect the Quality of Life of the Colombian people. There are variables that have a direct causal relationship with the Quality of Life of an individual in the Colombian context; they are determinant factors. However, variables affecting indirectly the Quality of Life or its determinant factors are also taken into account.

5.2.3.1 Assumptions

Before going into the details of the model it is important to make clear that this model is preliminary and it is subject to study and improvement. Moreover, it is developed on the basis of various assumptions, which have to be taken into account for the model's validity. Some of the assumptions and considerations are:

- Quality of Life for a Colombian varies depending on whether you are a campesino (peasant) or a resident of a city. Since currently more than 70% of Colombians live in urban areas, this model has taken account of this situation. Nevertheless, most of the factors could be seen as being the same but with different intensity.

- Various variables conceived from the indicators of sustainability for the three subsystems —human, support and natural— were studied and selected as influencing the Quality of Life of a Colombian. Each of these variables selected is linked in the influence diagram with the subsystem that it comes from, referring to Bossel's model.

- The intensification of the internal armed conflict was selected as an indirect parameter. The assumption is that an individual is not directly involved in the armed conflict (belonging to guerrillas or paramilitaries or army groups) or that he/she is not a victim of the crossfire. However, phenomena like displacement, danger and psychological effects, like fear, are assumed to be the influence or consequences of the conflict.

- Poverty as a variable here refers to measurements based on income. The non-satisfaction of basic needs, another parameter selected, covers housing conditions and crowdedness, number of dependants on one income, and access to basic public services such as potable water, sanitation, education and health.

5.2.3.2 Description

Quality of Life in Colombia is affected by various determinants that are reflected in the indicators from all subsystems—human, support and natural—shown earlier. Trends in indicators, such as poverty, social security cover, unemployment rate, size of the informal sector, housing affordability, crime rate, and income distribution, all affect in some way, directly or indirectly, the Quality of Life of every Colombian. The present trends in these

variables have in common that they influence harmfully the Quality of Life. For example, both the increase in poverty and the decrease in housing affordability mean a decrease in Quality of Life. In addition, society has degraded as a result of more than 40 years of the political and social struggle combined with phenomena like narcotic trafficking and corruption.

On the other hand, there are other variables that are supposed to influence beneficially the state variable, Quality of Life. Discussed indicators within the human and support subsystems, such as access to education, life expectancy and population growth rate, showed that there were elements that could result in an improvement in the Quality of Life of Colombians. However, present trends showed that some of these indicators have started to decline; for example, progress made in access to education some years ago have not resulted in better lives for some people due to the current high unemployment rates

Similarly, indicators from the natural subsystem were considered as well. The environment is supposed to have a positive relationship with Quality of Life; however, as mentioned earlier, for a Colombian urban dweller it is different. The urban environment is crowded cities, lack of public space and green areas, long hours commuting, polluted streams and air, which certainly have a negative impact on the Quality of Life.

In summary, only few variables representing the most crucial connections with the state variable are selected. It is important to notice that all these variables are not independent; they are interrelated so divisions or combinations made here are just for illustration and easy understanding of the model. The list of parameters selected for the conceptual model of Quality of Life is:

- Increase of poverty (measured in terms of income)
- Non-satisfaction of basic needs (education, housing, water, etc)
- Deterioration of society
- High level of unemployment
- Intensification of the armed conflict
- Increase in the cost of living
- High level of corruption

- Lack of access to and/or enjoyment of water

Subsequently, the polarity and direction of the connections between these variables and the state variable is established. That is both whether the Quality of Life is affected positively or negatively by the annotated variables, and whether the connection is direct or indirect. The map of all these interrelated variables is shown in the influence diagram presented as Figure 5.4.

5.2.3.3 Influence Diagram

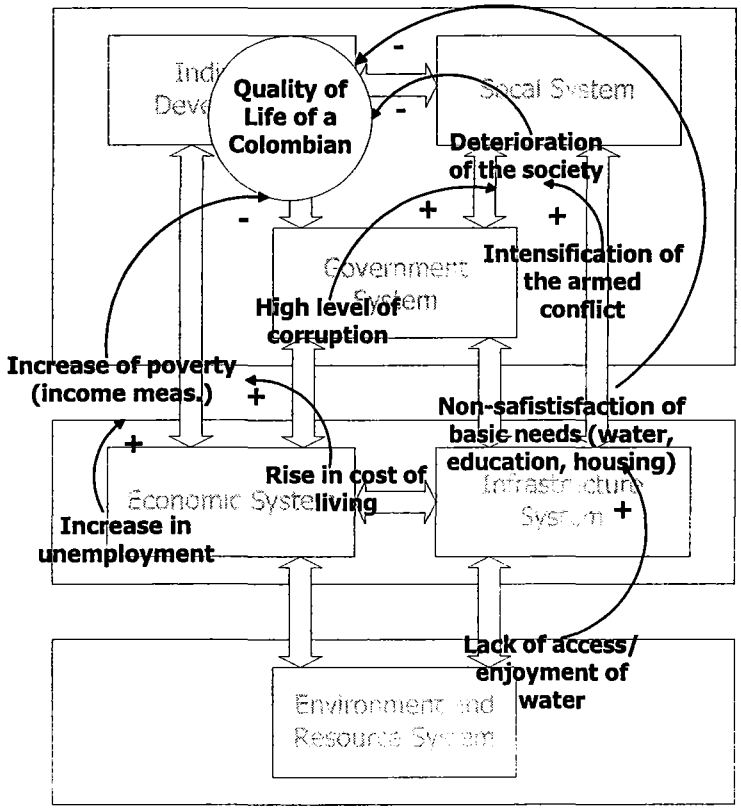


Figure 5.4 Proposed conceptual model for the potential of Quality of Life

Note: In the upper part of this diagram Socal should read Social

In this influence diagram the state variable is represented in a circle whereas the parameters are shapeless. The model appearing in grey is Bossel and it is overlapped by the conceptual model for Quality of Life, as a potential within human subsystem, appearing in black.

Reading the influence diagram of the model makes it possible to construct a picture of the behaviour of the state variable. Thus, Quality of Life in Colombia is influenced by three major variables with a negative polarity: deterioration of society, increase of poverty, and the non-satisfaction of basic needs. These variables in turn are influenced by other parameters that affect indirectly the Quality of Life and which come from different subsystems and from different links between the subsystems considered.

Rises in the cost of living and increases in unemployment influence with positive sign the poverty variable. High levels of corruption and intensification of the armed conflict influence a variable named here as deterioration of society, again with positive polarity. Lately, lack of access to water is one of the forces that increase the non-satisfaction of basic needs and comes from the link between the support system and the natural system.

There are no feedback loops easily observed in the model. Rather, the links are cause and effect connections. As mentioned earlier all these variables are not independent, so it is not possible to formulate objective conclusions about the resulting trend in the Quality of Life by judging individual trends. However, Quality of Life as a stock variable is decreasing as a result of the marked trends in the crucial parameters.

5.2.4 Water Resources as a potential of the Natural Subsystem

The selection of **Water Resources** as a **potential** of the natural subsystem and therefore of Colombia is more straightforward. Understanding the key roles of water in the sustainability of Colombia is the central research element of this thesis. Besides, water is a vital constituent for sustainable life of any community on Earth.

Water resources are assigned in Bossel's model to the natural subsystem as part of nature's endowment and stock of renewable resources. Furthermore, water is present in various linkages between natural and support and human subsystems. Precisely, these linkages determine the growth or depletion of water as stock or potential.

The potential of Water Resources is shown in Figure 5.5 in relation to Bossel's generic model.

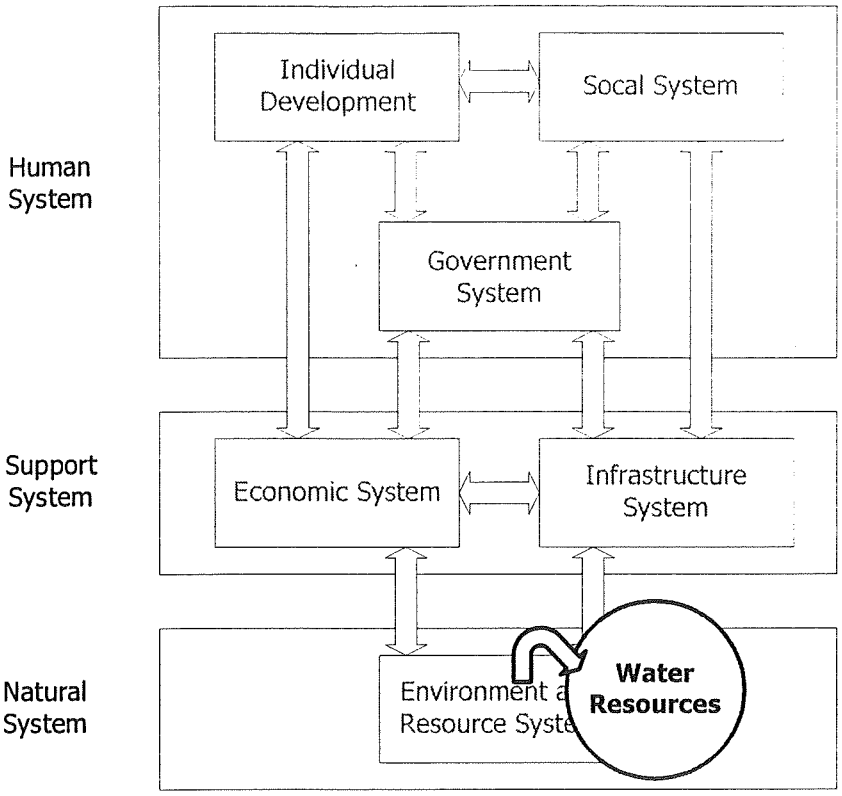


Figure 5.5 The Potential of Water Resources within Bossel's model for the anthroposphere
Note: In the upper part of this diagram Socal should read Social

5.2.5 Conceptual model for water resources as a potential of the Natural subsystem

The dynamics of water resources and their complex interrelations or linkages can be investigated through the elaboration of a conceptual model of 'Water Resources' as the state variable. This model is also based on the indicators of sustainability for Colombia as a way to identify the parameters affecting the state of the water resources.

5.2.5.1 Assumptions

The assumptions taken into consideration for the development of the conceptual model are mentioned as a starting point. This model also has a preliminary character and it can be revised and improved.

- It is acknowledged that water has its own system, the hydrological cycle, which is a closed system, that functions within the natural system.

- The model focuses on fresh water resources only. Seawaters and glaciers (ice waters), which in Colombia are highly significant (especially the former, having access to two Oceans), are not explored here for simplification.

- All uses of water such as domestic, industrial, agricultural and electricity generation are clustered initially under a parameter named according to demand and use. Similarly the disposal of wastewater refers to all of these uses. Later on, a particular use, domestic water, will be discussed since it has an interesting link with the other potential of Quality of Life

5.2.5.2 Description

Water Resources are influenced in various ways. In the human and support systems water was mentioned in indicators such as the Percentage of People Without Access to Basic Public Services and the Unsatisfied Basic Needs, referring basically to the access of Colombians to potable water.

Trends in these indicators showed that there was an improvement in accessibility of drinking water (among basic public services) mostly up till the 1990s (see Table 4.14 in chapter four), and predominantly for urban areas. This fact together with the urbanisation trends meant an increase in demand and use of the available water resources.

More recently the urban growth rate has slowed down, although the demand for water is still increasing. Moreover, other interconnected issues such as poverty in the new urban settlements and poverty of the rural migrants have resulted in lower affordability of water services. Therefore, the accessibility started to decline again and there are still many Colombians lacking proper water in rural and urban areas. This again does not mean a lower demand; rather it means an unequal distribution of the water resources.

Increases in demand and use of water represent a stress on water sources and reservoirs. Colombia's richness in Water Resources is being affected by incessant consumption from

domestic, agricultural, industrial and electricity generation sectors. Particularly, rapid urbanisation, which implies the issue of industrialisation in the city and countryside (agricultural production and hydroelectricity), is a determinant that negatively influences Water Resources.

On the other hand, in the natural system the indicator Unpolluted Waterways showed how pollution of water in Colombia is very significant. Rivers and lakes are being charged continuously with contaminated water due to lack of adequate infrastructure and inappropriate management. This is a relevant variable that also harmfully affects the state variable.

Another indirect indicator that shows effects on Water Resources is the Loss of Forests. This figure has notably risen in the tropical rain forest areas of Colombia as shown in Table 4.23 (chapter four). One of the major consequences of deforestation is the loss of vegetation cover required for proper functioning of the water cycle and subsequently the loss of streams and reservoirs.

In brief, the list of parameters selected from this analysis of indicators and variables affecting Water Resources is given below. The influence diagram showing positive and negative links between these parameters and the state variable is presented in Figure 5.6:

- High and rapid urbanisation
- Continuous increase in resource demand and use
- Lack of conservation
- Real valuation of water
- Disposal of wastewater without treatment
- Inappropriate management of water systems

5.2.5.3 Influence Diagram

According to this influence diagram the state variable Water Resources is affected by three major variables and these connections have a negative signs. This means that these variables change in the opposite direction to the state of the Water Resources.

One of these major parameters is the continuous increase in resource demand and use within the infrastructure system, which in turn is affected directly and with positive polarity by the high and rapid urbanisation that comes from the social system. Disposal of wastewater without treatment, another major variable, also comes from the infrastructure system and its linkages with the economy systems. Lastly, the other major variable is the lack of conservation and real valuation of water, which is placed in the economy system.

The last two major parameters mentioned are influenced positively by a parameter named 'inappropriate management of water systems'. This is a factor that influences indirectly the state of Water Resources and comes from the government component of the human system.

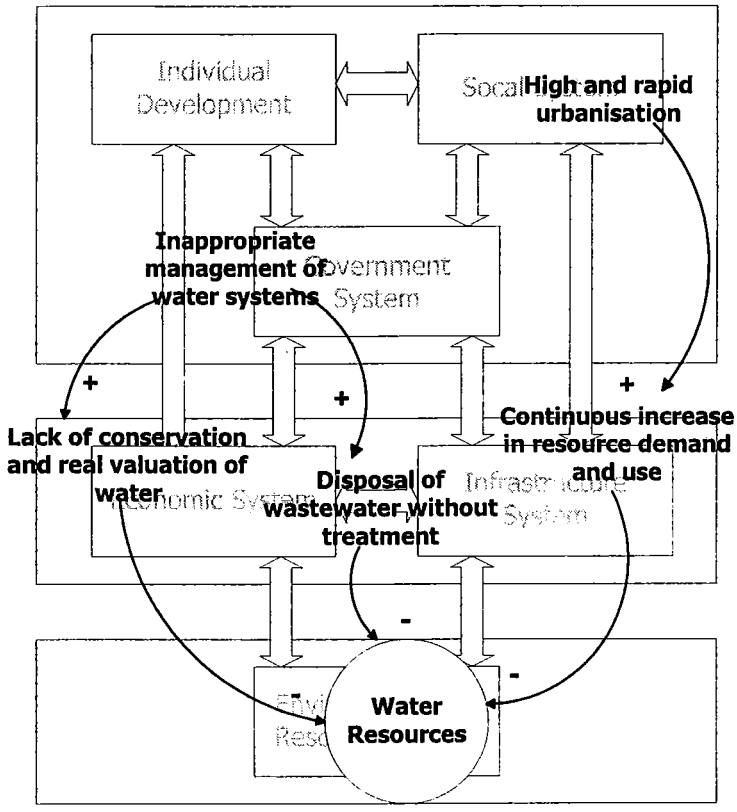


Figure 5.6 Proposed conceptual model for the potential of Water Resources

Note: In the upper part of this diagram Socal should read Social

As a consequence, from trends in these variables and the assumed interconnections the state of Water Resources in Colombia is conspicuously deteriorating. This can be

interpreted as the stock or potential of water resources being depleted and that there is no visible force or influence[14] within the system to take this state to equilibrium.

In addition, this conceptual model is telling us that the main parameters affecting Water Resources come from the linkages between the infrastructure, economy, social and government systems. For example in urban areas, water supply and disposal structures are controlled by water tariffs and pollution taxes and they are built in response to a demand.

These linkages are very relevant since the valuation of water, and hence the state of water, depends on the human perception and use of it. Nevertheless, there are other factors that determine the way people interact with water. These can be explored by analysing the connections between the two selected potentials, Quality of Life and Water Resources in Colombia, and consequently gaining insights of broader implications with regard to the sustainability of the whole system.

5.2.6 Linkages between the two potentials through conceptual models

Through the readings of the conceptual models for Water Resources and Quality of Life it can be seen that there is a connection between the two. In the model for Quality of Life, water is linked with the state variable indirectly through a variable describing the satisfaction of basic needs. Similarly, Water Resources has a link with the human system by means of the demand and use of the resource. What these links have in common is that they are located or related to the support system, as presupposed by Bossel's model.

Accessibility to Water is the element that can summarise these links. Basically, it is via accessibility that people interact with water. Obviously, there are some assumptions supporting this last statement, and some of which were mentioned for the respective models. The urban character of the relation is one of them. People of the countryside or living in forest areas (indigenous peoples) relate differently to water. Moreover, within urban use there is a differentiation between domestic, industrial and other uses.

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[14] It is acknowledged that there are in Colombia environmental regulations for the use and contamination of water, through resource consents and taxes. However this analysis is based on the information derived from the sustainability indicators chosen, where there is no evidence of effective impact of those regulations in the overall state of water resources.

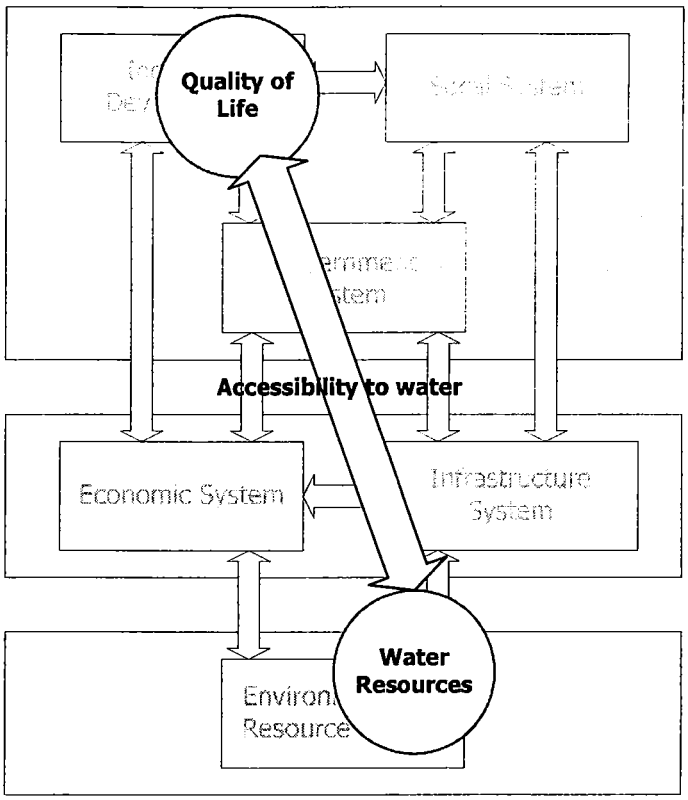

Figure 5.7 The link between Quality of Life and Water Resources via Accessibility within Bossel's model

Note: In the upper part of this diagram Socal should read Social

With the purpose of investigating this link of accessibility, the domestic use of water in urban areas is selected. There are various elements in this link that can be worth looking at and also the possibility of coming across feedback loops. Therefore, an influence diagram is attempted below to visualise this link of accessibility between the two variables, Water resources and Quality of Life, and the constituents' elements.

In addition, one of the aims of elaborating conceptual models is the possibility of analysing the balanced or unbalanced parts of a system and finding out leverage points. Leverage points are those elements that can apply more control over the system and produce change. This is particularly important for unbalanced systems or those having positive or reinforcing feedback loops as explained earlier.

5.2.6.1 Description

Based on the previous conceptual models, four elements were identified related to accessibility to water:

- Affordability of water services
- Management of water systems
- Cost of water supply and treatment systems
- Sources of water of good quality and quantity

Affordability of water services is one component of the Quality of Life for an urban resident. Being able to bear the cost of water services and therefore enjoy them adequately is a way to achieve a better quality of life. Management of water systems and Cost of water supply and treatment systems are two elements, within the infrastructure and economy systems, that describe the collective administration of the resource for its distribution and use. Finally, Water of good quality and quantity illustrates the state of Water Resources that are of use for urban dwellers.

5.2.6.2 Influence Diagram

The cause-effect relationships between these elements can be established in accordance with the trends deducted earlier for Quality of Life and Water resources.

- Decrease in Quality of Life means a decrease in Affordability of water services
- A reduction in financial resources for water services results in deficient Management
- The management of water directly affects the state of water sources, therefore a deficient management causes losses of water in quantity and quality; this implies a deterioration in Water Resources
- The decrease in available water, results in the increase of the costs of supply and treatment systems
- This in turn directly affects the affordability of water services; with higher costs there is lower possibility of paying for them; and as a consequence of deprivation of water there is a deterioration in the Quality of Life.

These interconnections can be appreciated in the influence diagram shown in Figure 8.

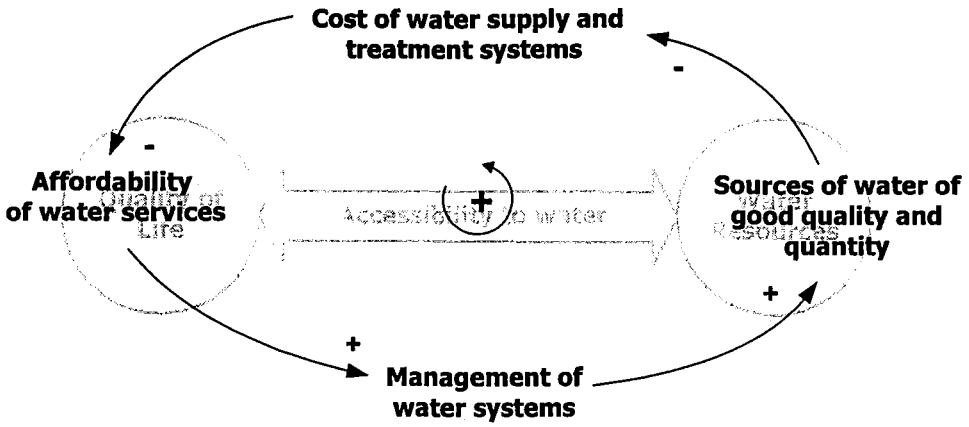

Figure 5.8 Influence diagram of the Accessibility Link between Quality of Life and Water Resources

5.2.6.3 Feedback loops

Taking into account the signs of the relationships considered in this model and this description a positive feedback loop is found. Decrease in affordability of water services results in a decrease in water availability (by means of a deficient management). This increases the cost of water services, which decreases affordability.

Consequently, the system tends to run leading to a situation that is unbalanced or out of control. This unbalanced loop representing the connection and deterioration of Quality of Life and Water Resources is a vital finding. Since maintaining the identified potentials, Quality of Life and Water Resources, is a requirement to achieve sustainability of the whole system, attempts to fix this unbalanced loop can make a contribution to the sustainability of the whole system.

5.3 Summary

This chapter has demonstrated how the system of Colombia is not offering a sustainable living to its people. Further, Quality of Life and Water Resources were determined to be essential potentials of the system. Water accessibility was deduced as the key link between the two essential potentials and a conceptual model indicating a feedback loop of positive

polarity was drawn. Affordability of water and water management are the two main elements of the feedback loop.

Accordingly, the next chapter deals with the possible actions that can be suggested to change the overall polarity of the waster accessibility loop and turn it into a negative feedback loop (balanced system). This will be done through the identification of leverage elements and approaches to water and sustainability. These possible actions and approaches are the basis for recommendations to address sustainability, as ultimate aims of this research.

Chapter 6. Determining Approaches to Address Sustainability

The purpose of this chapter is to place the findings of the analysis of sustainability for Colombia, done through conceptual models in the previous chapter, and discuss them in the context of other approaches to sustainability found in the literature.

The analysis showed how there is a positive feedback loop in the conceptual model linking Quality of Life and Water Resources, accessibility to water being the key element. To go further and attempt to modify the unbalanced loop, it is necessary to discuss some framework issues about management of water and its relation to sustainability. Therefore, the discussion includes arguments of researchers involved in resource management as well as sustainability. Economic, technological, political and social views are discussed and the need for an integrated and holistic approach to sustainability is inferred.

The outcomes of the discussion leads to the proposal for a holistic approach to addressing water accessibility and subsequently sustainability in Colombia, as the ultimate aim of this research.

6.1 Approaches to water and sustainability

In the analysis it was found that there are certain potentials within the system of Colombia that are necessary to maintain in order to achieve sustainability of the whole system. Quality of Life and Water Resources were found to be two essential potentials. Moreover it was deduced that the link between these two potentials, Accessibility to Water, is even more crucial for sustainability in Colombia because of its interconnections with other elements of the system: human, support and natural subsystems.

The Water Accessibility link was found to be a positive feedback loop, which is a self-reinforcing non-equilibrated situation, directly affecting the state of Water Resources and Quality of Life. The positive feedback loop means that the potentials are connected in a

way that the deterioration of one leads to the deterioration of the other and this situation will continue without stabilisation. Affordability of water and water management are the major elements intervening in this positive loop.

Since the state of the two selected potentials—Quality of Life and Water Resources—is vital for the total system of Colombia, their deterioration implies that the country is not sustainable and viable according to the principles of Bossel's system theory for sustainability followed in this thesis.

To address the unbalanced loop, or in other words to find ways to resolve the unsustainability of one of the key elements of the system, it is necessary to identify actions that while they contribute to the change of a specific variable in the loop considered, also contribute to a holistic perspective for achieving sustainability. These are recommendations that initially are primarily towards the water link but also have an impact in the sustainability of Colombia as a whole.

Accordingly, approaches to dealing with sustainability and the role of water were researched. Divergent views were found and they are discussed in the light of the systems approach followed in this thesis. The holistic perspective is also included in the discussion. Further, the findings of this thesis are related through all the debate.

6.1.1 Divergent Arguments

In the relevant literature it is very common to find phrases such as sustainable water management, sustainable wastewater treatment and sustainable technology, sustainable infrastructure and urban sustainability. Most of these papers address the issue of sustainability of water in isolation. Their focus is narrowed to technologies or economics and generally they do not relate the problem of water unsustainability to broader areas. This is as though researchers see only the bottom part of Figure 3.2 (natural system: environment and resources) or the left part of Figure 5.8 (sources of water) without stressing the interconnection with other elements in the system.

In the following, different views dealing with the relation between sustainability and water are presented. Representative authors have been chosen to illustrate each subject.

6.1.1.1 Technological view

Butler and Parkinson suggest that "Sustainable management of water as a resource must seek to satisfy current demands and environmental objectives whilst purporting to satisfy the projected future demands of growing population and the need to protect the long-term availability of natural resources" (1999:61). This view of sustainability is based on the definition of sustainable development that was reviewed and discussed in the first chapter[15].

The statement emphasises the purpose of the meeting the water demand, current and projected, without questioning if the demand is right or whether the resource is equally distributed. It is about demand, not about needs. It refers also to maintaining and protecting the water resources in the long term. Both satisfaction of the need for water and water protection are significant aims for sustainability; however specifications on how the two can be achieved together are made through technology only.

Butler and Parkinson (1997) along with Harremoës (1997) and Larsen and Gujer (1999) suggest a comprehensive list of strategies for sustainable water technology. The principles are well grounded in closed cycles and anthropogenic limits, ranging from non-use and reuse of the resource to natural or biological technologies for treatment of wastewater. These are indeed the technological options to be used. Nevertheless, there is no mention of how all people can access the technology and whether the technology satisfies the real needs of all people, including developed and less developed nations.

Similarly, Rosegrant in his paper *Water Resources in the twenty-first century: challenges and implications* (1997) presents solutions for meeting the demand for urban water in the present water shortage but he goes further, linking the rural and urban dimensions of water management. He suggests that new sources of water are needed but the costs are increasing steeply, so it is necessary to make savings from existing waste and address inefficient water use in urban water systems and reallocate water from agriculture. Moreover, he

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[15] The issue of the definition of sustainability is discussed in the first chapter of this thesis. There is recognition of the difficulties with definitions of sustainability when they are placed in the context of developing nations. Sustainable development concerns not only intergenerational but also interregional equalities in developing nations.

introduces the problem of costs and suggests that the full social, economic and environmental cost must be considered. Therefore, the technological solution is tied to economics.

6.1.1.2 Economic view

For Braden and van Ierland (1999) economics is the key element to sustainable water management. When they place their assertion in the context of sustainability they state that "As it applies to water management, sustainability amounts to maintaining the abundance and quality of water resources to sustain ecosystems and support future human needs while also meeting current household and commercial water requirements" (1999:17).

Although Braden and van Ierland affirm that sustainability is an "extraordinarily broad and challenging concept" (1999, 18) and beyond doubt that "supplying water in a sustainable manner requires first, balancing the social uses of water with its availability in nature" (1999:19), they conclude that an effective pricing strategy will promote sustainability.

They consider that economics, through various market valuations methods, is a necessary tool to obtain sustainable water systems. The selection of a 'sustainable' option is based on costs; capital, social and environmental impact costs. This is a narrow view of sustainability. It allows economically viable projects for sustainability without considering the appropriateness of the water uses. Further, Braden and van Ierland do not consider whether these methods contribute to effective distribution of the resource and the satisfaction of all people need for water, independently of their different economic backgrounds and conditions.

In addition, use of the Contingent Valuation Method is advised, to indicate the market value of clean water (Braden and van Ierland, 1999). This method is based on individual willingness to pay for improving environmental quality or to accept environmental deterioration. This precisely illustrates the point: individuals from communities such as the one studied here, in Colombia, are not able to pay for water services even if they want to do so. Therefore if economics is the only criterion for sustainability, people who cannot afford water services at the market price are left out and the infrastructure systems continue

running only for those who can afford them. Thus the resource is not equally distributed and this situation is not truly sustainable for all.

Currently there is substantial debate about the character of water, whether it is a fundamental human right or a public good or a private consumption item[16]. Privatisation and economic globalisation are current trends that affect water management all over the world (Barlow, 2001) [17]. The lack of agreement on the real valuation of water demonstrates that there is a great need to question the role of economics allowing the market to govern the allocation and access to water.

Further, Braden and van Ierland conclude that the challenge is to develop more efficient and cheaper technologies that can contribute to sustainable development (Braden and Van Ierland, 1999). However, taking into account the argument about the role of the market for pricing water and its relationship to accessibility, the actual challenge is to develop a new valuation system so that all communities can afford the technologies. This implies significant shift towards an ideal system, that could make water accessible for all.

Varis and Somlyódy specifically studied the question of affordability and its relation with the problem of sustainable development in the paper *Global urbanisation and urban water: can sustainability be afforded* (1997). They consistently affirm that "the present tendency of considering water as an economic good, despite its many merits, includes severe pitfalls, especially in terms of inability to cope with the poor, the environment and the informal sector" (1997:28).

As a result of the analysis of current figures Varis and Somlyódy (1997) conclude that current expenditure in water and sanitation is not sufficient to improve the required water and sanitation services. Moreover, the projected requirements cannot be supported in

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[16] See for example http://www.canadians.org/blueplanet/conf-2001-e.html with regard to the International Forum People and Nature: An International Forum on Conservation and Human Rights

[17] See also http://www.infoagua.org/ for evidence of privatisation in Latin America and Colombia and http://www.canadians.org/blueplanet/index2.html for the active campaign carried out against trade and privatisation of water in Cochabamba, Bolivia, in December 2000

developing countries, which have the highest urban population growth rate, so that unmet needs for water and sanitation will continue growing.

6.1.1.3 Political view

The study by Varis and Somlyódy also reinforces the need to look at the problem from another perspective. They state: "besides the economic issue, it is typically a political question of priority setting how to provide services for those very poor and those living on an illegal basis" (1997:26). Hence, other variables such as political and development decisions have to be taken into consideration.

Rosegrant (1997) admits that national water policy reforms have to take place in order to ensure the most efficient use of available water supplies, and that water should be treated as a scarce resource. Although this is a sensible proposal, nonetheless, policy reforms in this case should not be limited to urban water supply. They have to consider various sectors in conjunction; health, energy, agriculture and even education.

As it was demonstrated for Colombia, water scarcity is directly related to the overall management of the resource. Variables from the individual development, social and government systems, such as the level of poverty, urban growth and the level of corruption, are all related to the management of water. Therefore reform policies that have a similar aim are needed in every sector. In a complex system, it is not possible to fix one problem without considering the interrelationship of its parts.

Supporting this is the rapid urbanisation phenomena occurring in most developing countries. As shown for Colombia, urban pressures on water resources are resulting in decreasing availability of water sources and increasing costs for services. Varis and Somlyódy show that as a city grows the unit cost of water tends to grow sharply (1997). Interestingly, Harremoës comments, with regard to population concentration in cities, that "the technical question becomes one of transport of water and/or food, which is simple compared to limiting/relocating people" (1997:19). Would not it be easier, and cheaper in the long term, if policies for development were made in a way that population were shifted or de-concentrated out of the mega city via promoting development in various and smaller cities? This reiterates the proposal for a change to an ideal system in developing countries

and confirms the complexity of the changes required in the whole system. This change demands significant reforms in the development pattern of these countries and in the case of Colombia it involves solving the difficult problem of violence in the countryside.

On the other hand, Larsen and Gujer (1997) the authors of *The concept of sustainable urban management* believe sustainability is a global issue, whereas urban water management is regional or local. In the systems perspective, the relationships between local and global matters are undoubted; there is no possibility of achieving global sustainability if a local community, in any country, is not having sustainable living. Therefore efforts made internationally are required. Moreover the implications of international economics for the local water supply in relation to privatisation were shown in the economic view; therefore international agreements that have a holistic view of sustainability are most needed in this global society.

However, local autonomy is something to be rescued and reinforced in international politics and the political view of sustainability. The solutions and proposals in this field of water management have to rise from the grassroots level to be really effective and impact on sustainable living. In other words it needs stakeholder involvement. Martin O'Connor in the first issue of the International Journal of Water indicates, "..water management is not mostly about a technical problem, nor even an economic problem. It is a problem of civil society, political process and collective understanding" (2000:7). Therefore, people require awareness and education to understand the whole picture and make local decisions with regard to their resources based on their needs. They also, and most importantly, require a political ground or environment that truly takes into account local initiatives.

6.1.2 Holistic view

In view of the benefits and shortfalls of various and independent views regarding the connection between sustainability and water, a holistic perspective becomes essential.

Concluding comments by some authors constitute a valuable contribution to this aim. For example Harremoës (1997) emphasises that environmental problems can no longer be evaluated in isolation; they have to be viewed with respect to the totality of the system. Varis and Somlyódy (1997) recognise the holistic view; they conclude: "fragmented,

strictly sectorial approaches to development of human habitats may create more problems than it can solve, as has been witnessed many times" (1997:31).

In this regard, there is a novel and comprehensive proposal that takes into consideration an integrative perspective. Gallopín and Rijsberman have discussed global scenarios for water management (2000). They explored three different approaches to deal with the problem that face water and its linkages with sustainability today, taking into account social, demographic, economical, environmental, technological and governance sectors.

The first scenario, Business as Usual (BAU), is based on the assumption that improvements in economic growth and water technology will be enough to solve the problem. However, they demonstrated that BAU for water leads to regional and global water, economic and social crisis. The second scenario, Technology, Economics and Private sector (TEC), believes that unprecedented efforts and investments are required. Although improvements in water are achieved, TEC for water results in high social and political costs and the permanent establishment of a dual society. The third scenario has a different approach because it assumes a strong global commitment. It is about changing Values and Lifestyles (VAL) for all, both North and South, and it attempts to solve other interconnected problems such as poverty. Therefore VAL offers the best results for water resources and stakeholders in the long term.

Since the VAL scenario is an integrative and systematic approach to sustainability and water it will be explored further to gain insight for the recommendations of this thesis. Figure 6.1 presents the details and interrelations between actions suggested in VAL.

6.1.2.1 The Values and Lifestyles (VAL) scenario

The basis of this approach is that the solution of complex water issues cannot be achieved without addressing the interlinkages between technological, demographic, economical, social, environmental and institutional issues (Gallopín and Rijsberman, 2000).

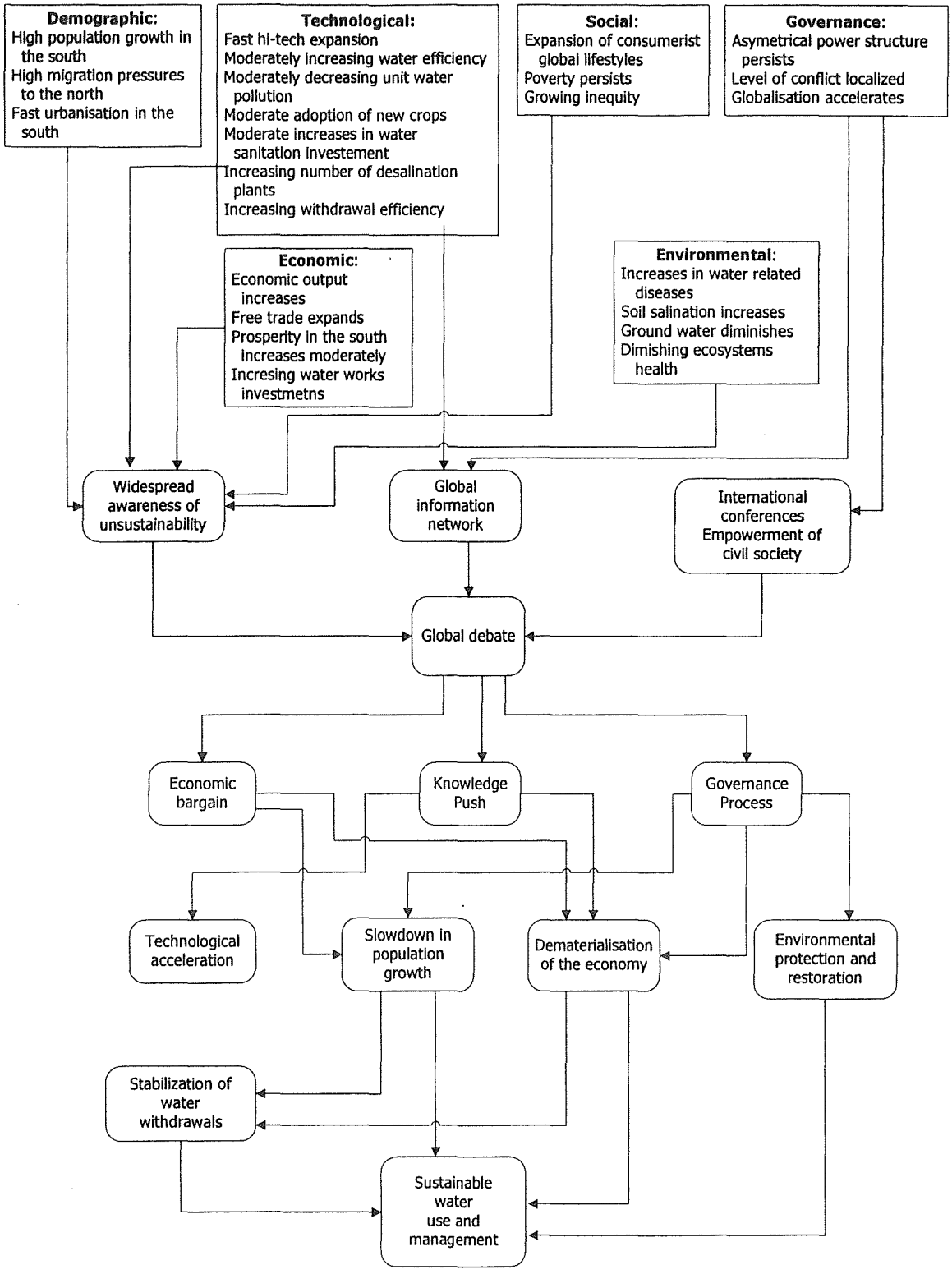

Figure 6.1 The unfolding of the Values and Lifestyle Scenario for global water management (Gallopín and Raijsberman, 2000)

At the very top of Figure 6.1 the current characteristics of every sector are presented on a global scale. Thus for example in the social sector growing poverty and inequity are

mentioned and in the governance sector globalisation is identified. Further down appear the first consequences of the current trends: awareness of the unsustainability, global networks and empowerment of civil society. These consequences maintain that for global sustainability, economic development is not sufficient and that environmental stewardship and social improvement are also urgently needed.

In this VAL scenario, as a result of the generated global debate, an economic bargain takes place, resulting in the dematerialisation of the economy. This process occurs mainly in the countries of the North while the basic needs of the population of the South are being satisfied. Consequently, there is a more balanced quality of life on the global scale. A knowledge push is established and also changes in the governance processes, in which bottom-up, decentralised, self-organising and interconnected governance networks evolve. These processes assume a strong emphasis on education and capacity-building at the national and local levels.

At this point the authors believe governments, together with community organisations should explore alternative combinations of water pricing, taxation, voluntary contributions and cost-sharing schemes to foster efficient use of water (Gallopín and Rijsberman, 2000). However, as was discussed earlier in the chapter, debate and reforms could go further to include a change in the economic valuation systems.

In addition, the VAL scenario suggests that traditional technologies that were socially and ecologically sustainable, but not economically efficient, will become available. Also, ecosystem restoration and rehabilitation becomes a leading sector of the economy and as a result, environmental quality improves significantly. Finally, consensus should resolve all conflicts; VAL involves cutting back armies and achievement of peace as inputs for the transition to sustainability and eradication of poverty.

In summary, VAL suggests very important changes to solve the water problems. It involves inter-and intra-sectorial actions on local, national and global scales; and enables improvements for people's quality of life at the same time as improving water resources. This is the main linkage with the findings of this thesis.

6.2 Addressing sustainability in Colombia with a holistic approach

A holistic approach is consequently appropriate to obtain a balance in the water accessibility positive feedback loop found in the sustainability analysis of Colombia. Improvements to water accessibility will be closely linked with improvements in the Quality of Life of Colombians and in the state of the Water Resources, thus addressing sustainability of the country as a whole.

Principles derived from a systems view, allowing for technology, economics, political and social interrelations, should be followed. Although there are intricate issues that cannot be altered except by profound changes, what is attempted here is to propose an ideal system that can be built based in small and interconnected steps. In this scenario water accessibility is a small but very significant part of the system.

In the case of Colombia the issue of violence shows the complexity of the system: water and sanitation, poverty, unemployment and crime are interconnected. A way to overcome violence is by solving basic needs that will enable people to think differently and have other values to tackle difficult issues such as narcotrafficking, corruption and violence.

Water accessibility becomes a basic need for this system. Satisfying the water accessibility need is not only about finding suitable technical solutions, it is about understanding the importance of the interconnections with the other parts of the system. It is about economics, involving changes in the current valuation of resources in society; it is about social and political transformation so that stakeholder people have true autonomy to make and execute their decisions with regard to resources. It is about a broader frame in which human needs and rights overlap with lifestyles, duties and limits globally. These are fundamental values required for sustainability.

In particular, John Peet in his paper *Resource Management may be the answer but what is the question?* (1999) makes it clear that "situations of sustainability and development imply a moral standpoint, from which ethical positions can be derived and be clearly

stated" (1999:4) and these "moral standpoints and priorities have to be determined by society itself, via appropriate processes" (1999:3).

Hence, with appropriate processes, people's involvement, understanding of the system interconnections, and with new fundamental values and ethics, communities can change institutions, politics and economics, aiming for the satisfaction of their basic needs and ultimately for sustainability.

A start can be made by creating, supporting and educating current grassroots movements in Colombia that are aiming to improve their quality of life and their water access conditions. All points discussed here can help them as tools, or as Gallopín and Rijsberman, believe as "a common framework for diverse stakeholders to map and address their concerns and identify alternatives" (2000:39).

Finally the following chapter will present the principles for recommendations to be implemented in Colombia dealing with water accessibility and aiming for sustainability in a holistic way, together with the conclusions of the overall thesis.

Chapter 7. Conclusions and Recommendations

7.1 Conclusions

This thesis strives to gain an understanding of the intricate issues surrounding ideas such as development, people's quality of life, water resources use and sustainability in the context of a country as complex as Colombia. The initial hypothesis was to determine whether Colombia could offer to its people a sustainable living. Having dealt with this, the following question was to determine the key role of water in the sustainability labyrinth and the ways to address the problems standing in the way of water and a sustainable living.

As a learning process this thesis has been a *koru*—Mäori word for spiral—. It has started and come back to various points through thinking and re-thinking the meaning of these complex ideas concerning Colombia.

The meaning of what sustainability involves was examined in chapter two. The definition adopted for the study was *sustainable living*, since it recognises all communities of the world, emphasising that improvements for peoples' quality of life are required now and also in the future. This definition also stresses awareness of the need for minimise impact on nature of all human activities.

The use of systems thinking was one essential element for the research, mainly discussed in chapter three. Systems thinking (that is, a system is more than the sum of its parts) is central in dealing with complexity and with sustainability. Specifically Hartumt Bossel's analytical framework for defining sustainability indicators based on systems thinking was selected. The satisfaction of basic needs is indispensable for a system to be sustainable and viable. Bossel's method studies any system and analyses whether all its basic needs—*orientors*—are being satisfied through the use of indicators. In other words, the indicators' objective is to assist in identifying the fundamental needs of a complex system. The *orientors* of a system are existence, effectiveness, freedom of action, security, adaptability, coexistence and psychological needs.

Following Bossel's structure and method, a set of 72 indicators was determined for Colombia; however, only 31 indicators were investigated and expanded further due mainly to limited available information. This is shown in chapter four. The chosen indicators provided the essential information required for the sustainability analysis (chapter five).

The general analysis of all indicators concluded that Colombia, as a whole system, is not offering a sustainable living to its people. Trends in interrelated indicators such as the increase in poverty, unemployment rate and cost of living, and intensification of the internal armed conflict gave evidence of the lack of satisfaction of Colombians' basic needs of existence, freedom of action and security. Besides, indicators such as loss of biodiversity and pollution showed how the impact of human activities in the country has not been adequately addressed.

A specific analysis was elaborated through the use of conceptual models. Models are pictures or representations of the world; they enable us to understand the complexity of a system by way of identifying causal relationships between its elements. For Colombia, Quality of Life and Water resources were identified as two key *potentials*—Bossel's term for a stock of a vital asset that must be maintained in good state in order to contribute its share to the development of the total system. Conceptual models were drawn for these two *potentials* illustrating the variables affecting their state.

Furthermore, a strong connection between the two *potentials* was found. The link between Quality of Life and Water Resources via Water Accessibility was established. Affordability of water services and management of water systems were pinpointed as the key elements for access to water for Colombians in urban areas. A feedback loop of positive polarity linking these elements was determined in the conceptual model. This is an unbalanced situation representing the deterioration of Quality of Life and Water Resources by the decrease in Water Accessibility.

Consequently, Water Accessibility became one of the basic needs of the system that should be satisfied to achieve sustainability of the whole. Approaches to address water and sustainability were then explored. Technological, economic and political approaches were seen as divergent views but also as necessary subjects to be discussed in thinking about

water accessibility and sustainable living for all communities. Economic revaluation of resources, appropriate natural technologies and community initiative and autonomy were some of the subjects identified as needing to be considered.

The discussion of chapter six led to postulate and explore a holistic approach to address water accessibility and therefore sustainability in Colombia. The complexity of the unsustainabilities of the system (Colombia) and of other interactive systems (the global community) requires understanding of the interconnections and interrelations of all parts.

Ultimately, if Colombians can meet their basic needs, of which water accessibility is just one, it will free them up and enable them to tackle other issues related to quality of life in their society such as corruption and violence, as well as appropriate management of their resources. This will give rise to sustainable living for the people of this land in South America.

7.2 Recommendations

The basic recommendation of this study, rather than a list of instructions to follow, is an invitation to think differently. Through systems and holistic thinking we can gain understanding, becoming aware of the complexity and the interrelations in our system. This in turn will guide the decisions that involve our communities and our resources, all around the world.

I agree with my colleague David Chittenden when he affirms that the next step, in walking towards sustainability and redirecting development is to 'communicate these concepts and frameworks [systems and holistic thinking] to people in leverage positions in society, that is, in local and national government' (Chittenden, 2000 p171). True, they write the policies. But I go further because I believe we all are leverage points: we are part of a community in which we live or identify with and it is in our hands to make a change and gain awareness within ourselves and build collectively an ethics, as proposed by John Peet, in whatever position we will hold in society.

To inspire readers to start building an ethics and work towards a sustainable living for all, from the place where this thesis was written, a koru of traditional Mäori ethics by a Mäori professor is reproduced. I am sure Colombian indigenous communities would have as much to say about their environment, because indigenous peoples all over have learnt various lessons, which we, *pähekä* and *mestizos*[18] should acknowledge:

'This is not a hierarchy of ethics, rather, they begin in the centre of the spiral and together with the traditional values they constitute a Pacific Polynesian view of holism and way of linking humanity and economy in a relationship of reciprocity and respect, They can be stated as follows:

te ao märama, ethic of wholeness, cosmos

mauri, ethic of life essences, vitalism, reverence for life

tapu, ethic of being and potentiality, the sacred

mana, ethic of power, authority and common good

hau, ethic of spiritual power of obligatory reciprocity in relationships with nature

wairuatanga, ethic of spirit and spirituality

tika, ethic of right way, of the quest for justice

manaakitanga, ethic of care and support, reverence for humanity

whanaungatanga, ethic of belonging, reverence for the human person

te ao hurihuri, ethic of change and tradition

kotahitanga, ethic of solidarity

kaitiakitanga, ethic of guardianship of creation" (Henare, 2000:3).

[18] Mestizo is the word in Spanish for people who have Spanish and Indigenous descent. Päkehä is the word in Maori for European or not Maori (Mäori Dictionary, 2001)

Glossary of Terms

Orientors: In Bossel's framework the orientors are the basic needs of a system. The satisfaction of these needs is a requirement for the system to be viable and sustainable

Potential: In Bossel's methodology the term potential denotes a stock or capital of a vital asset, which can grow or depreciate, and must be maintained in good state in order to contribute its share to the development of the total system.

State variables: In systems analysis the variables which condition is central for the development of the system are called state variables. In an interconnected system they depend upon other variables called **parameters**. The parameters' values affect the state variable but they are independent of the system. The way all variables are interrelated can be expresed through a model of the system.

Conceptual models: They are simplified pictures or representations of real systems. In this study conceptual models were developed for identified **potentials** for the sustainability of Colombia as a complex system. Thus, the potentials are the state variables of the conceptual models.

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